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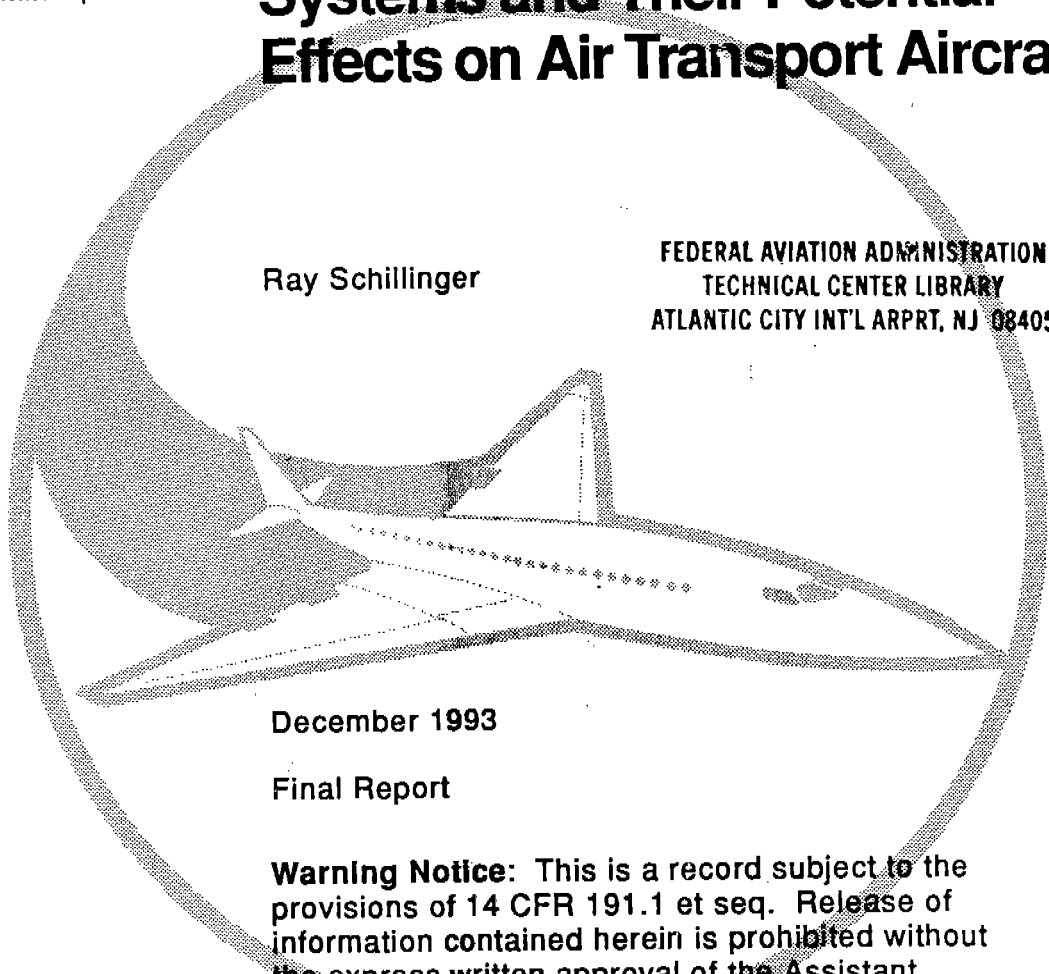
DOT/FAA/CT-93/18⁸¹

FAA Technical Center
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Man Portable Air Defense Systems and Their Potential Effects on Air Transport Aircraft

Ray Schillinger

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December 1993

Final Report

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PREFACE

This document contains the initial results of a study and test relating to the potential threat of Man Portable Air Defense Surface to Air Missiles to air transport aircraft and was prepared by the Aviation Security Research and Development Service, Aircraft Hardening Division.

The actual test was conducted at Davis-Monthan Air Force Base, Arizona, on August 25 and 26. The test team included the following participants:

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EXECUTIVE SUMMARY

As a result of the terrorist bombing of Pan American 103 over Lockerbie, Scotland, three major actions were taken by the United States Government to enhance the aviation industry's capability to counter such threats:

a) The President appointed a Commission on Aviation Security and Terrorism to address related security issues and to make recommendations to ensure the future safety of aviation systems.

b) Congress passed the Aviation Security Act, which mandated the Committee on Public Works and Transportation to improve aviation security.

c) Congress passed the Aviation Security Improvement Act of 1990 to promote and strengthen aviation security through research, engineering, and development.

With these Research and Development (R&D) initiatives in place, and in coordination with the Assistant Administrator for Civil Aviation Security, the Federal Aviation Administration (FAA) devised an Aviation Security Research and Development Program (ASRDP) plan to implement the mandated recommendations.

Starting in the late 1960's, small IR-guided Man-Portable-Air-Defense-Systems (MANPADS) emerged as a serious threat to military aircraft. Since that time the military has made considerable progress in reducing the vulnerability of their aircraft to hostile air defense weapons of all types. The designers of small IR guided missiles have responded by increasing the lethality of their armament systems to the extent that they are comparable in destructive capabilities to earlier vehicle mounted SAMs.

MANPADS are small by design and easy to conceal. They can be reconfigured or disassembled into components that can easily be shipped in a large suitcase. These systems are simple to use and require minimal training.

They are deployed worldwide and are readily available through legal and illegal means.

The purpose of this study is to present a basic understanding of MANPADS capabilities and characteristics.

RECOMMENDATIONS

1) Conduct a literature search relating to any items regarding MANPADS theory, capabilities, performance, and counter-measures. This will include inquiring data bases from government and industry.

2) Team up with various intelligence sources to determine a MANPADS threat to world-wide commercial air transportation.

3) After conducting recommendations 1) and 2) determine if there are any technical or intelligence gaps and pursue them.

4) Publish and disseminate, to the appropriate organizations, all findings relating to recommendations 1), 2), and 3).

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1.0 INTRODUCTION

1.1 Purpose

This report represents the initial results of an on going effort to determine the effects of a terrorist act against transport type aircraft. Where previously the threat was concentrating on a terrorist-concealed bomb within an aircraft, this test studied the effects of a Man-Portable-Air-Defence System (MANPADS).

The study within this report represents the results of a field test conducted at Davis-Monthan Air Force Base (DMAFB), Arizona, on August 25 and 26, 1993, involving the firing of two missile warheads, of the same model, at different locations against an actual aircraft structure.

These tests are part of a plan to develop a blast damage data-base which will provide design recommendations for aircraft survivability methods and techniques, airport security studies, and to further develop empirical and analytical techniques for predicting damage to future aircraft.

Because these base-line tests are preliminary the conclusions were limited and should be viewed cautiously.

1.2 Organization of Report

This document is organized in the following sections:

- Section 1: Introduction
- Section 2: Damage Fundamentals
- Section 3: MANPADS
- Section 4: General Test Description
- Section 5: Test 1 Internal Shot
- Section 6: Test 2 External Shot
- Section 7 Conclusion
- Section 8: Lessons Learned
- Section 9: Recommendations

1.3 Background

As a result of the terrorist bombing of Pan American 103 over Lockerbie, Scotland, three major actions were taken by the United States Government to enhance the aviation industry's capability to counter such threats:

- a) The President appointed a Commission on Aviation Security and Terrorism to address related security issues and to make recommendations to ensure the future safety of aviation systems.
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With these Research and Development (R&D) initiatives in place, and in coordination with the Assistant Administrator for Civil Aviation Security, the Federal Aviation Administration (FAA) devised an Aviation Security Research and Development Program (ASRDP) plan to implement the mandated recommendations.

Countermeasures to terrorist attempts to destroy commercial jet transports entail two elements of security:

- a) Preventing an explosive device or weapon from reaching an aircraft.
- b) Negating or minimizing the effects of an explosive device or weapon to increase the probability of survival.

The first element deals with personnel screening techniques, airport security, explosive detection devices, etc.. The second element is involved with the development of materials, designs, countermeasures and procedures to mitigate blast effects from aircraft, and methods for hardening aircraft.

1.3.1 MANPADS Threat

Starting in the late 1960's, small infrared (IR) guided MANPADS emerged as a serious threat to military aircraft. Since that time the military has made considerable progress in reducing the vulnerability of their aircraft to hostile air defense weapons of all types. The designers of MANPADS have responded by increasing the lethality of their armament systems to the extent that they are comparable in destructive capabilities to earlier vehicle mounted SAMs.

The current MANPADS are easier to conceal. Some models can be disassembled into a package equal to a large suitcase.

These systems are easy to use and require minimal training. They have no signal emissions and their quick reaction capability minimizes a gunner's exposure and warning time.

They are deployed world wide and are available on the arms market through legal, and illegal, means for about \$10K and up depending on the system acquired.

While attacks worldwide against civil aircraft with MANPADS were not very common in the early 1980s, incidents have been on the rise in the past eight years. Some examples include the following:

Country	Number of Attacks
Angola	6
Sudan	5
Afghanistan	4
Rhodesia	3
Georgian Republic	4
Bosnia	1
Costa Rica	1
Mozambique	1
Mauritania	1
Somalia	1
Armenia	1

As noted most of these attacks have occurred in countries caught in the middle of an insurgency or a civil strife. Two of the most recent attacks involved two Tupolev Tu-154s in Georgia, the former Soviet republic.

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1.4 Test and Study Objectives

The objectives of this test was the following:

- a) To develop and document base-line data on the effects of a MANPADS warhead on a transport type aircraft.
- b) To gain an understanding of the explosive effects of a MANPADS warhead on a transport type aircraft.
- c) To gain an understanding of MANPADS.
- d) To gain additional experience in testing protocols and procedures for subsequent tests with regard to studying blast effect.

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2.0 DAMAGE FUNDAMENTALS

2.1 Damage Mechanism

A damage mechanism is the output of a projected weapon that causes damage to the aircraft or intended target. It is the physical description of the tangible instrument or measurable quantity designed to inflict damage to a target.

Examples of damage mechanisms include:

- * Penetrators
- * Fragments
- * Incendiary Particles
- * Blast

2.1.1 Penetrators

A penetrator can be the core of a projectile, an expanding rod (associated with a continuous rod warhead), or a shaped charge jet. The damage processes associated with the penetrator are:

- * Ballistic Impact/Penetration
- * Hydraulic Ram
- * Combustion

2.1.1.1 Ballistic Impact/Penetration

Ballistic impact and penetration are the primary causes of the damage processes inflicted on a target. Initial penetration upon impact usually involves piercing the skin of the target.

Penetrators with soft cores generally flatten on impact and create larger holes than their initial diameter. When the penetration produces a clean hole, the section sheared out by the penetrator is called a plug. This type of penetration is called plugging or punching (Figure 2-1). For harder material, the penetrator must tear the surface during entry, and a petal-type protrusion surrounded by radial crack is formed. This type of penetration is called petalling (Figure 2-2).

The terminal effects of impact and penetration depend upon the material being penetrated. In the case of an aircraft structure (i.e., spars, ribs, skin, and longerons), penetration can lead to a loss of load carrying ability resulting in a loss of control of aerodynamic surfaces (i.e., ailerons, elevators, and rudder). Mechanical components can crack, jam, or sever. Damage due to penetrated engine components can lead to catastrophic engine failure, fuel leakage, engines fire, and secondary Foreign Object Damage (FOD) as a result of engine components severing at high speed.

Another result of ballistic impact and penetration as a damage process is called spallation (Figure 2-3). In spallation a penetrator impacts armor or a very hard structural material resulting in fragments spalling off the rear surface of the structural material. High speed impact generates an internal compression stress wave in the penetrator, or fragment, and in the target. Interaction within the target material between the initial compression wave and any reflected tensile stress waves off of a free surface cause high tensile stresses may result in pieces of the target material being ejected from the rear surface of the target material (or inside a target).

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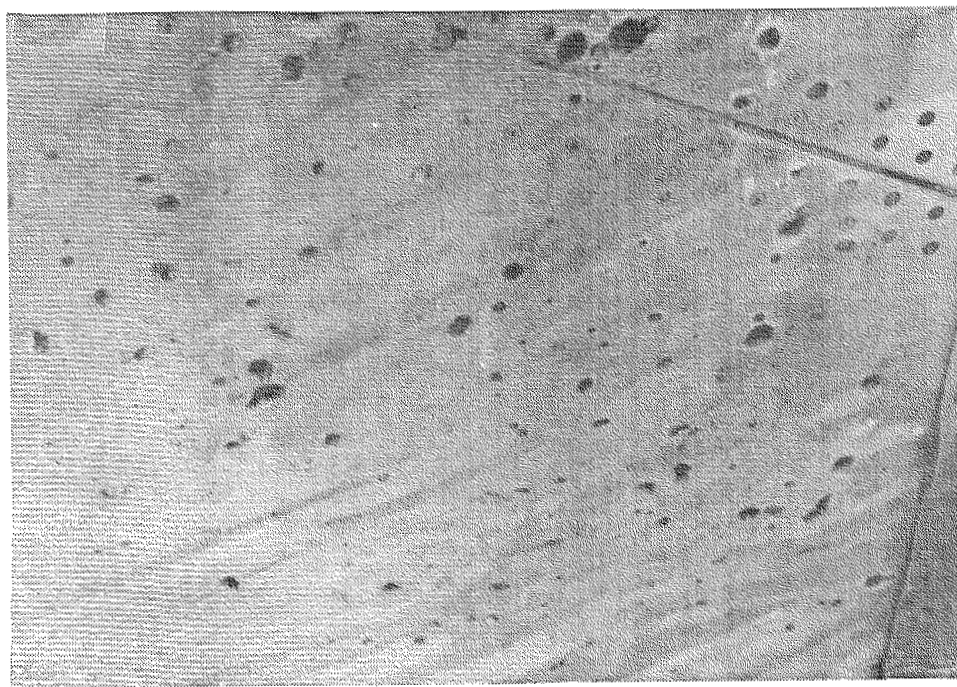


Figure 2-1 PLUGGING OR PUNCHING DAMAGE

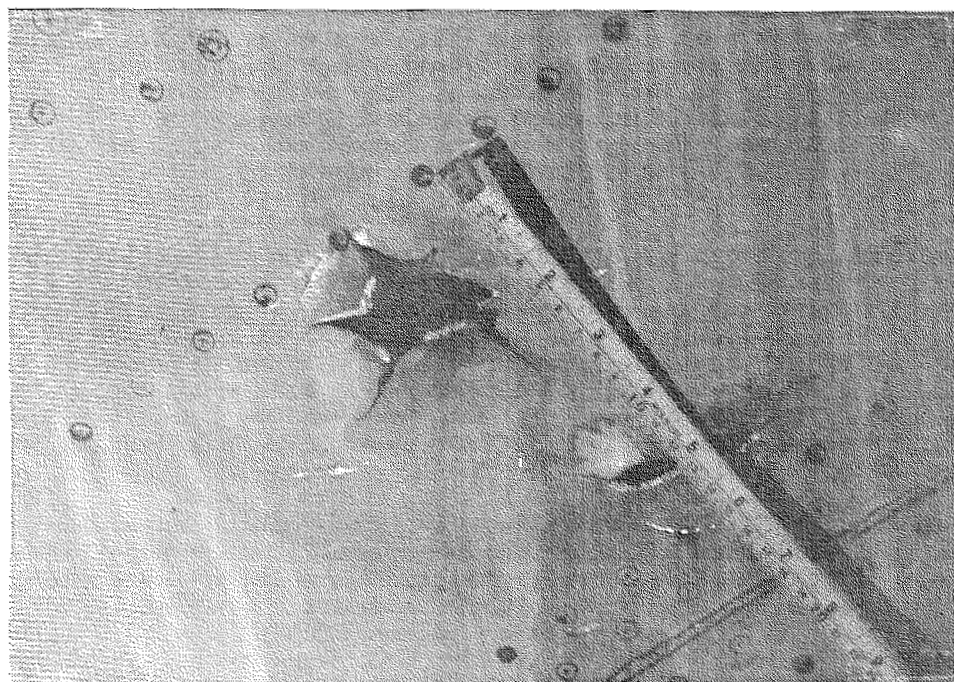


Figure 2-2 PETALLING DAMAGE

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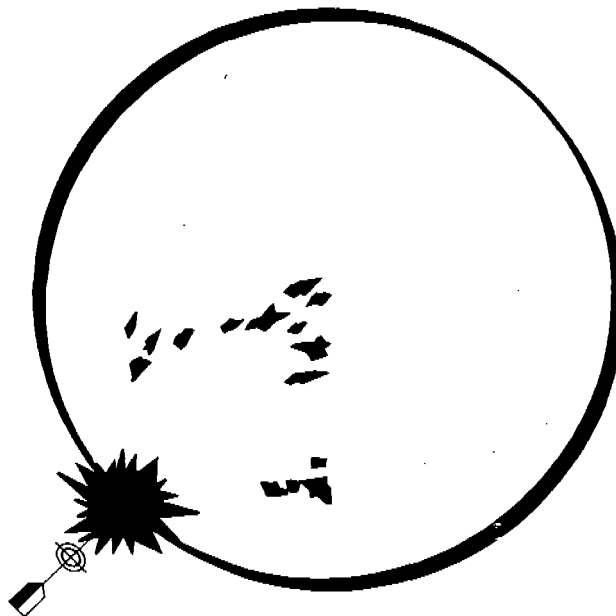


Figure 2-3 SPALLING DAMAGE

2.1.1.2 Hydraulic Ram

Hydraulic ram is the damage process that occurs when a projectile enters a compartment containing fluid. This damage process is divided into three phases; the entry phase, drag phase, and cavity phase (Figure 2-4).

The process is initiated when a projectile penetrates the wall of the container or tank and impacts the fluid. As energy is transferred to the fluid, a strong hemispherical shock wave centered at the point of impact is formed. This creates an impulsive load on the inside of the entry wall in the vicinity of the projectile's point of entry. As the penetrator travels through the fluid its energy is transformed into kinetic energy of fluid motion as the projectile is slowed by viscous drag. An outwardly propagating pressure wave is generated as fluid is displaced from the projectile path. In contrast to the pressure developed in the shock phase, the fluid in the drag phase is accelerated gradually, rather than impulsively, so that peak pressure is lower; however, the duration of the pressure pulse is longer. A cavity develops behind the projectile as it passes through the fluid, which is filled with liquid vapor evaporated from the cavity surface and with air which has entered the cavity through the entry hole. As the fluid seeks to regain its normal condition the cavity will oscillate resulting in the cavity phase.

This ram loading can cause tearing and petalling with openings larger than the actual entry point. Hydraulic ram can also be transmitted through the lines attached to the container causing failure along the attached lines or fittings.

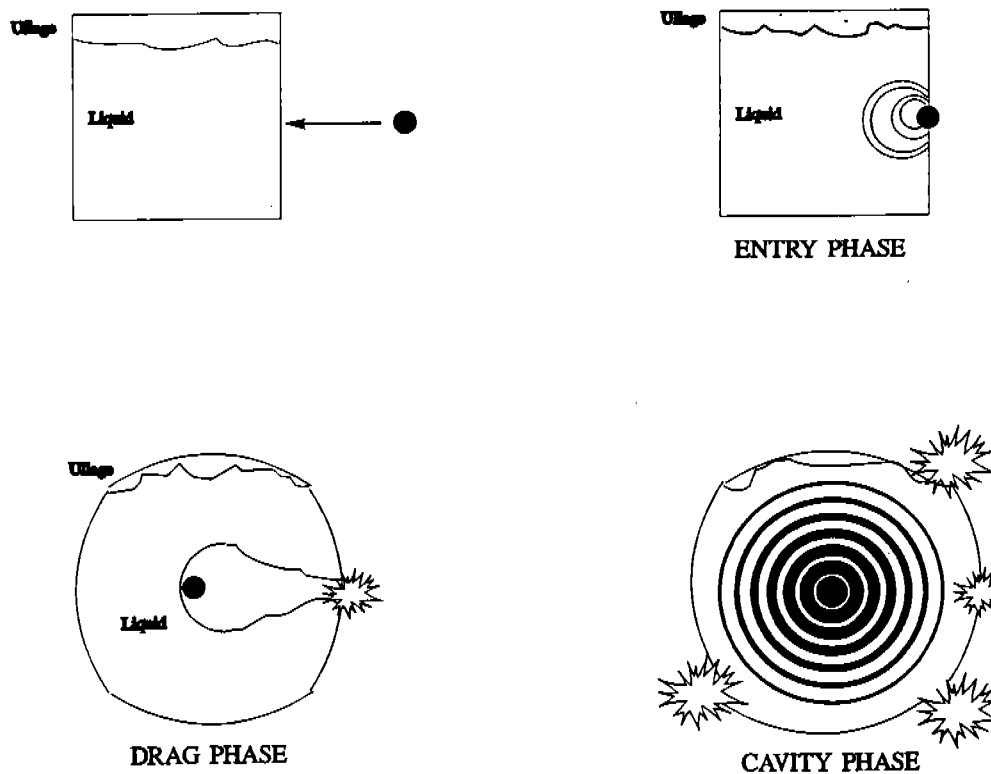


Figure 2-4 HYDRAULIC RAM

2.1.1.3 Combustion

A high-velocity metal penetrator that comes into contact with a metal target, or component, may produce incandescent metal particles or vapors that are a source of ignition for nearby combustible materials

2.1.2 Fragments

Fragments, unlike projectiles, are irregular metal particles varying in weight, shape, and velocity. They may be produced by the detonation of an explosive warhead or as a result of ballistic impact.

Fragments can be categorized in two areas:

- * Blast-Generated Fragments
- * Impact-Generated Fragments

2.1.2.1 Blast-Generated Fragments

Blast-generated fragments are a direct result of the detonation of munitions of which the fragments were a part or component of the munitions. They can vary in material, weight, size, shape, and velocity depending on the specific weapons system and its purpose.

Depending on the fuzing system utilized in the design of the weapons system the detonation can occur externally or internally to the target (i.e., proximity, contact, time-delayed, etc.). In addition, the size, momentum, and blast pattern of blast-generated fragments can be controlled by the warhead design to most effectively damage a specific target.

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The damage processes and terminal effects associated with blast-generated fragments are the same as, or similar to, those associated with a penetrator (section 2.1.1). However, the damage caused by fragments can be more severe than that caused by penetrators when a multitude of closely spaced fragments strike the target.

2.1.2.2 Impact-Generated Fragments

Impact-generated fragments may occur either as spallation (section 2.1.1.1) of the target material or by breakup of the weapon itself on impact.

In both cases, high velocity fragments are ejected inside and outside the target with the capability of generating the same damage processes as a penetrator. Impact-generated fragments also tend to disperse randomly from the point of impact and cause damage over a greater area as oppose to a single round.

2.1.3 Incendiary Particles

The damage mechanism as a result of incendiary particles include those chemical agents designed to cause combustion and which are added as a filler agent to certain projectile and missile warheads. In small arms projectiles, the incendiary material is located in front of the passive core and is initiated upon impact to the target. In a high-explosive warhead, any incendiary material is ignited when the warhead is detonated and dispersed by the explosion. Incendiary particles may also be generated by the high speed impact of a metal penetrator or fragment on the metal surfaces of a target.

The effective and wide use of incendiary munitions stems from the vulnerability of the aircraft fuel system to fire. Ignition and subsequent fire can occur within the ullage or vapor space of a fuel tank (figure 2-4). Fires can also occur in conjunction with a penetration damage process which involves fuel spilling from the fuel cell and collecting within adjacent voids or dry areas. It should be stressed however that fuel is not the only combustible material within an aircraft.

2.1.4 Blast

Blast is the rapid movement of a spherical pressure wave away from the center of a high pressure area (i.e., an explosion). The pressure in the blast above the ambient pressure is called overpressure with the peak overpressure occurring at the leading edge of the wave. A typical pressure wave is depicted in figure 2-5 for several values of time (t) after detonation. The important parameters of the wave are the peak overpressure and the duration of the positive overpressure phase of the blast.

The pressure loading on a target caused by blast from an explosion is called blast loading. It is the damage process associated with blast, and the combined effect of the dynamic pressure loading (drag) and the overpressure loading.

Dynamic loading is produced by the velocity of the air in the blast with respect to the aircraft. It is a drag loading on the target itself. This damage process causes the secondary damage of structural deformation, bending and tearing of cantilevered structures, and dynamic removal of any loosely secured attachments.

Overpressure loading results from the effects of the overpressure in the blast striking and moving over the surfaces of the target. Note in figure 2-6, PRESSURE OBSERVED AT DISTANCE (D), that the initial

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overpressure is followed by a period of underpressure. This compression/decompression effect can result in additional structural damage even though the specific component was not located directly facing the blast.

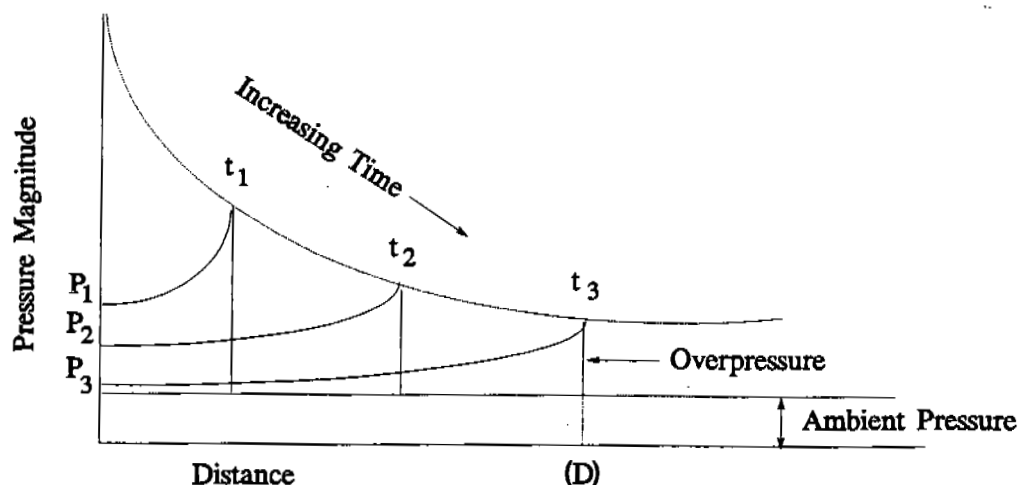


Figure 2-5 PRESSURE OBSERVED AT DISTANCE

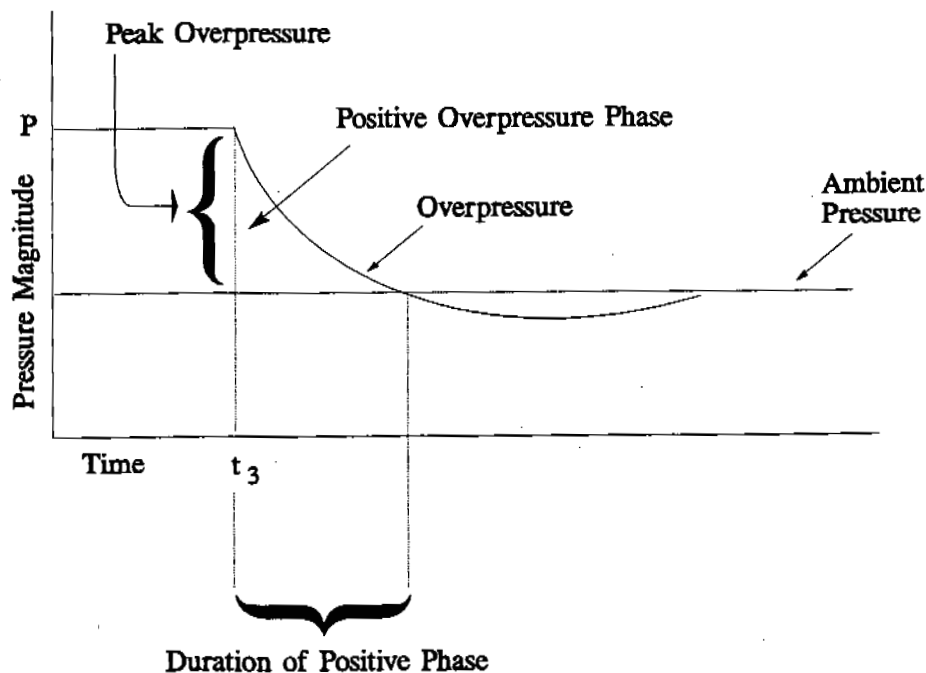


Figure 2-6 BLAST WAVE PROPAGATION

3.0 MANPADS

3.1 MANPADS Fundamentals

The MANPADS, shoulder fired, surface-to-air-missile is an air defense system typically used by forward deployed military units as a means of protection from low altitude aircraft. Versions of these systems have been developed and deployed worldwide for over 25 years.

In general, the majority of MANPADS use the heat generated by the target aircraft to guide itself to the target. In older systems the missile tracked solely on the heat generated by the target's engine.

Advanced seekers are now capable of detecting several heat sources, such as exhaust plumes or skin emissions.

MANPADS seeker heads can be broken in three categories:

- * Spin-Scan Seekers
- * Conical-Scan Seekers
- * Imaging Seeker

3.1.1 Spin-Scan Seekers

A first-generation seeker unit, the spin-scan seeker is typically referred as a rear aspect, hot-spot tracker. Target energy is gathered by the optical system of the seeker and focused on a rotating reticle. The reticle then chops this target signal into a band of pulses, or spokes. Chopping the signal allows the seeker to determine phase information (target direction) and the amplitude of the tracking error.

Most spin-scan seekers use amplitude modulation (AM) tracking. The detector output is fed into a band-pass filter which strips the DC signal from the source resulting in an interrupted sine wave (or missile audio). The signal is then passed through a demodulator (or envelope detector), which produces a square wave output. The square wave output is fed into another band-pass filter which strips the spin frequency of the reticle from the signal.

The resultant signal is a sine wave. The amplitude of the sine wave corresponds to the magnitude of the tracking error and the phase of the signal corresponds to the direction of the tracking error. These signals are then fed into the seeker head, which tracks the target, and into the missile guidance control unit, which steers the missile.

3.1.2 Conical-Scan Seekers

In a conical-scan seeker the reticle is fixed and does not spin. Instead a mirror within the seeker head is spun causing the target image to be scanned in a circular path around the outer edge of the reticle.

When the target is centered in the seeker scan, the detector produces a pulsed signal similar to the spin-scan seeker. However; as the target leaves the center of the reticle, the output of the detector is a frequency modulated (FM) sine wave. The depth of this frequency modulation is directly proportional to the amount the target is displaced from the center of the seeker scan. The signal is processed by passing through an FM discriminator whose output is an AM modulated signal with amplitude proportional to the amount of frequency modulation present.

The output signal is then passed through a demodulator, as in the spin-scan seeker, to produce the target tracking signal information.

3.1.3 Imaging Seeker

The newest generation MANPADS guidance system is the imaging seeker. These seekers do not use a reticle. Instead, the system incorporates an array of detector elements that detect environmental energy and produces a spatial map of the scene. This energy map is converted into a television-type display which allows the missile to track on the actual image of the target as oppose to its radiated signal.

3.2 IR Sources

IR missiles use energy emitted by the target in the IR spectrum. All object emit some form of IR signal (the hotter an object is the more energy it will emit). As temperature rises, the wavelength of the peak energy emission is shorter. A flare or an aircraft in afterburner may have a peak energy emission of 1.5 microns (μm), while an aircraft cruising may emit 3 to 5 μm .

The IR signature of a transport aircraft can come from a variety of sources (Figure 3-1). Sunlight glinting off the skin of an aircraft, the hot exhaust gas plume generated from an engine, the engines themselves, the metal parts heated by exhaust, and the skin heated from high speed air are all sources of IR energy that can be exploited with a MANPADS. This magnitude of IR signature is expressed as thermal power per unit solid angle or watts/steradian/micron (W/sr). A typical IR signature, in relation to the aircraft aspect can be depicted in figure 3-2. These individual aspect measurements can be compiled into a polar plot (figure 3-3).

Seekers, or detectors, on an IR missile can operate in several IR spectral regions depending on the detector material used. Earlier missiles used uncooled lead sulfide (PbS) detectors which could detect a target energy in the 1 to 2.5 μm range, whereas newer systems using cooled indium antimonide (InSb) can operate in the 3 to 5 μm band (figure 3-4). As stated earlier, older MANPADS relied mostly on attacking an aircraft from a tail aspect and tracking on hot engine parts; however, newer systems allow MANPADS to attack an aircraft from almost all aspects.

3.3 MANPADS Operation

On sighting a target, the gunner tracks it using optical sights. At the same time he energizes the missile guidance system. A buzzer within the system will inform the gunner when the target has been locked onto by the missile seeker. Upon firing, an ejector charge will propel the missile out of the launch tube. When the missile has cleared the gunner by a sufficient distance, the main rocket ignites and propels the missile to its intended target.

Appendix A discusses various MANPADS and their operations.

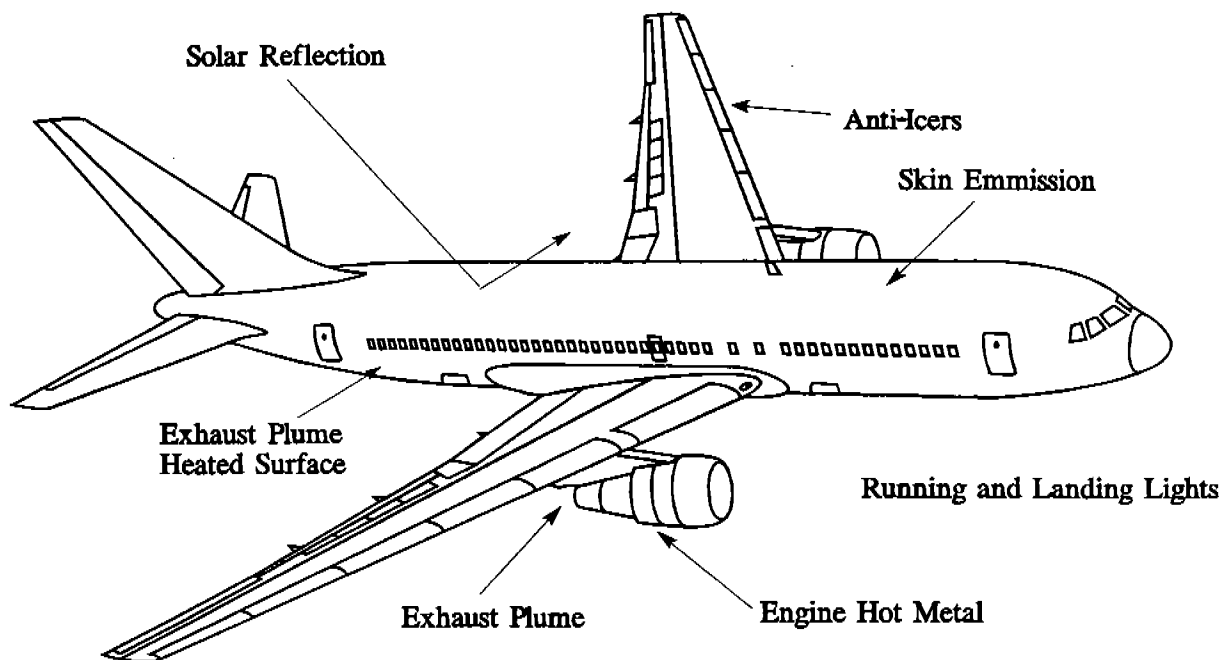


Figure 3-1 AIRCRAFT HEAT SOURCES

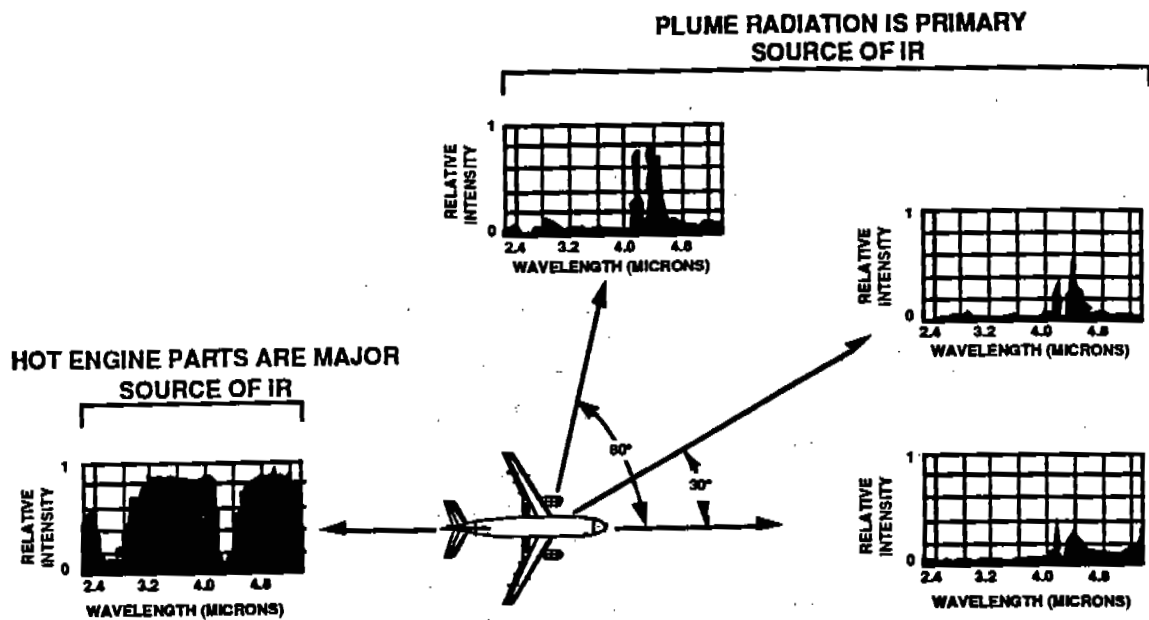


Figure 3-2 IR SIGNATURE AROUND TYPICAL AIRCRAFT

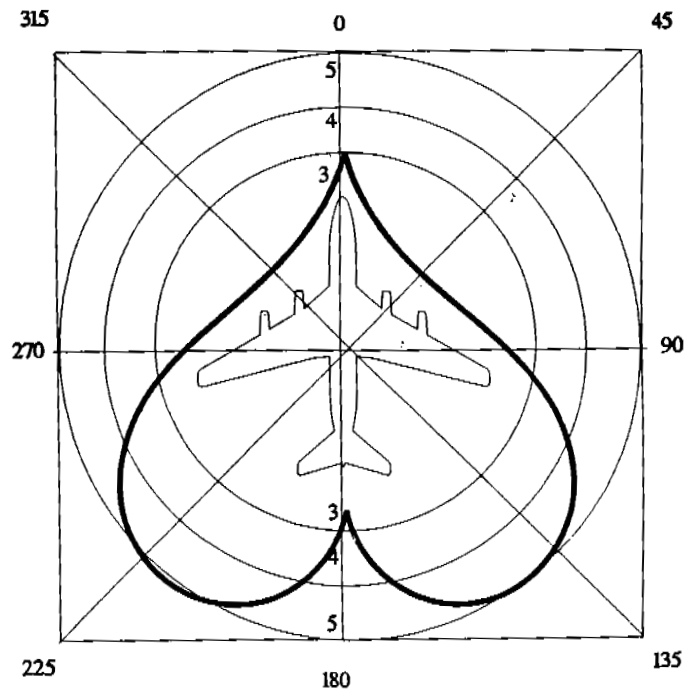


Figure 3-3 AIRCRAFT POLAR PLOT

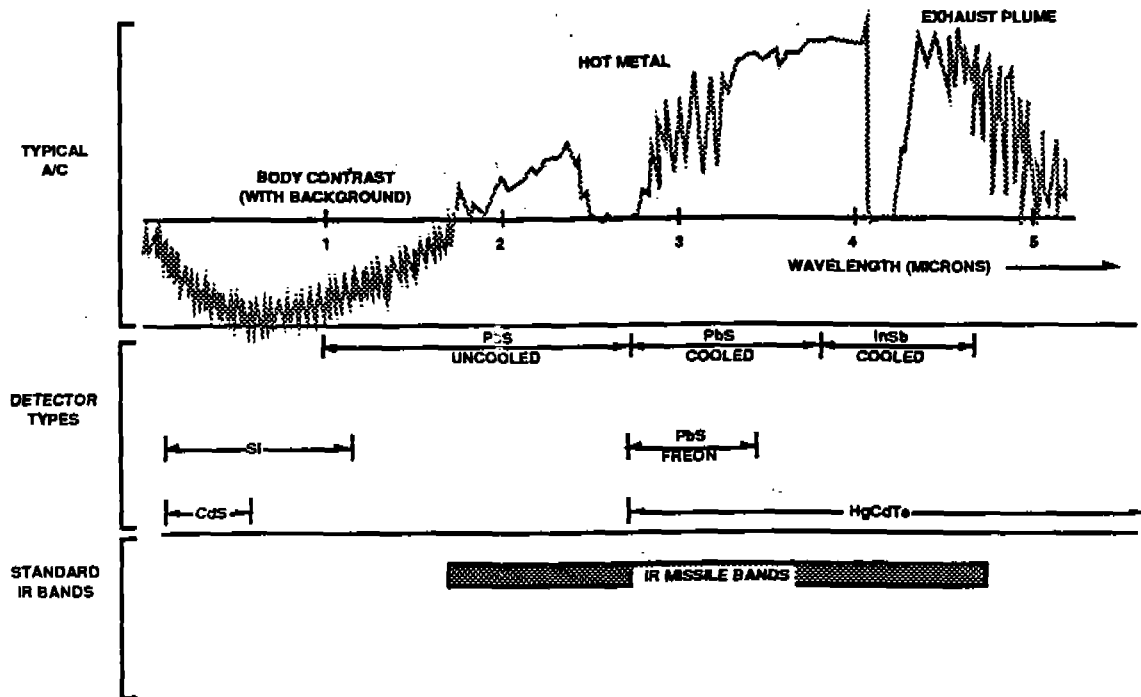


Figure 3-4 DETECTOR TYPES VS MISSILE SEEKER BANDS

4.2 Test Aircraft

The aircraft utilized for this test was a Boeing 720-B , tail number N330DS (figure 4-2). Although this aircraft was basically a hulk, the airframe in the areas tested was considered structurally sound for this purpose and provided a close representation of the current commercial fleet. For the purpose of this test a complete aircraft was not required because these tests were concerned only with a representative structure and not a particular type of aircraft.

Due to a prior test, N330DS had the following significant damage and modifications (figure 4-3):

- a) The aircraft was missing the entire skin surface and associated structures from station 420 to 600-J, and from the top of the floor beam (WL 208.1) up.
- b) A hole was blown just below the aft entrance door.
- c) All the engines were removed.
- d) The vertical stabilizer was removed.
- e) The forward and aft galleys were damaged.

A wing pylon was erected on both wings for support. The port wing's pylon was erected at approximately wing station 643 and ran parallel to where the outboard strut was situated, from the wing's leading to trailing edge.

To investigate the effect of a missile detonation to fuel tanks, the port fuel cells were filled with water.

The interior of the aircraft (where the internal test was conducted) was relatively intact (figure 4-4). Silhouettes were set up on all seats.

4.3 Test MANPADS

The MANPADS utilized for this test is a system that is deployed and has been used against aircraft, with results, in an operational environment.

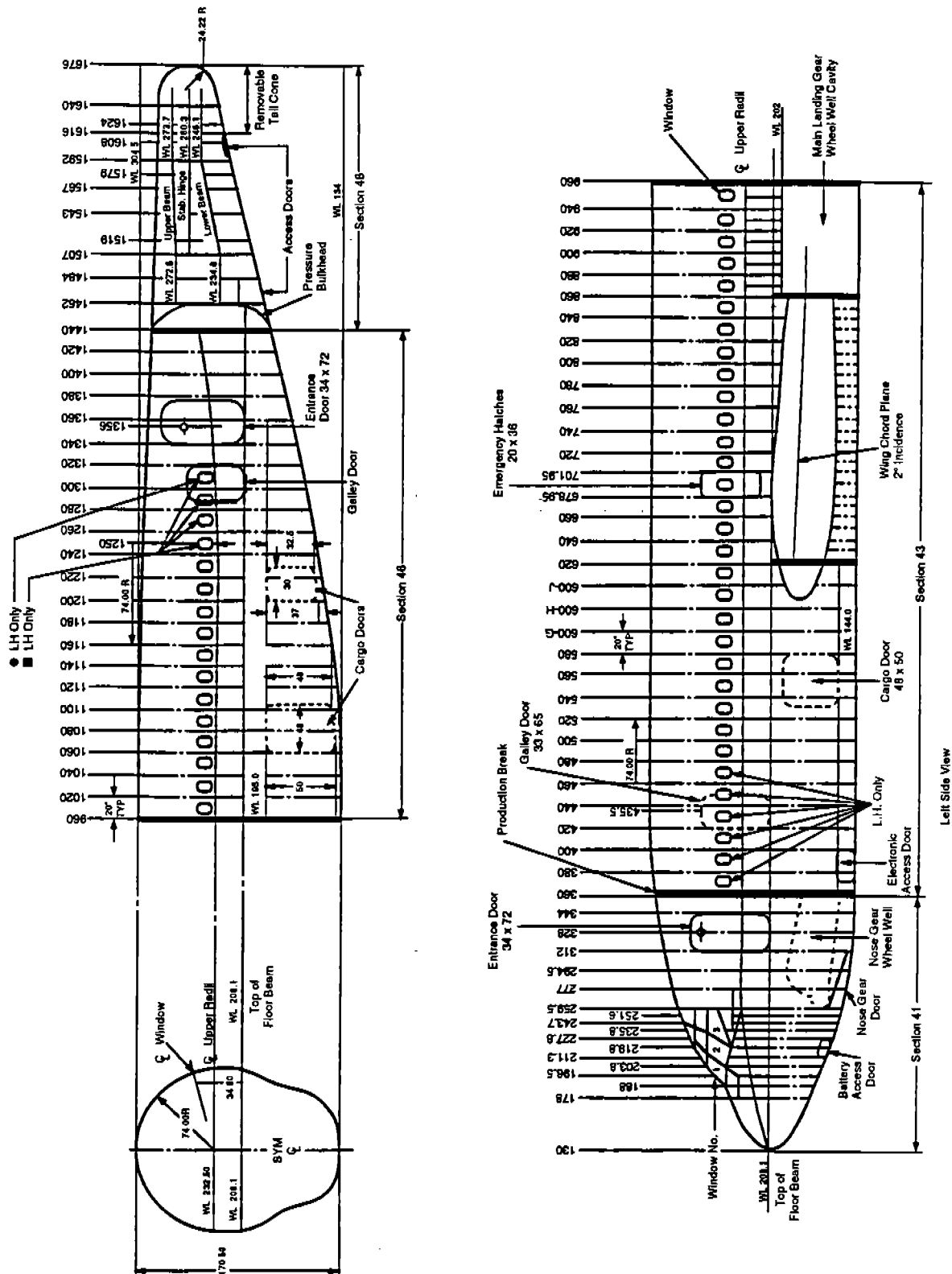


Figure 4-2 STATION DIAGRAM FOR BOEING 720-B

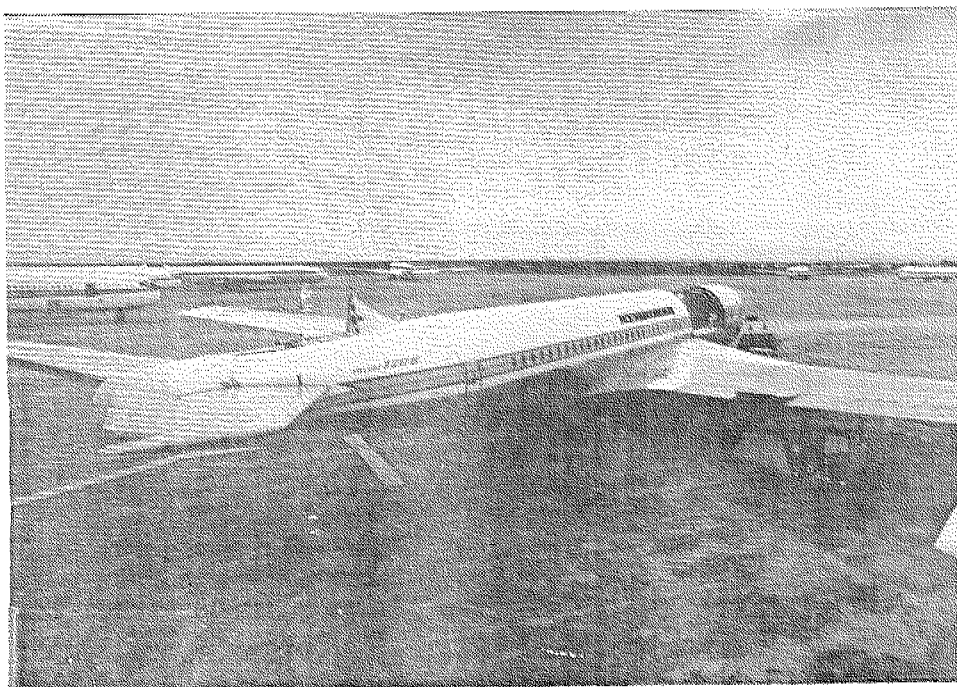


Figure 4-3 AIRCRAFT PRIOR TO TEST



Figure 4-4 AIRCRAFT INTERIOR PRIOR TO TEST

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4.4 Photographic Support

Photographic services were provided by the FAA Technical Center. A combination of photographic stills and high speed motion, and real-time video motion were utilized to document both test.

Equipment used on this test included:

- a. LOCAM High Speed Motion Picture Camera
Model: Redlake 12-283
Speed: 500 frames/second
Lens: 10mm
Film: Kodak 16mm 7296 color negative film
- b. Mitchell High Speed Motion Picture Camera
Manufacturer: Mitchell Camera Corporation
Speed: 128 frames/second
Lens: Bausch & Lomb 75mm/3inch zoom
Film: Kodak 35mm motion picture camera film
- c. PHOTEC High Speed Motion Picture Camera
Speed: 4000 frames/second
Lens: 210mm
Film: Kodak 16mm motion picture camera film
- d. Video Cassette Recorder
Model: Sony EVV-9000
Film: 8mm video
- e. Photographic Still Camera
Model: Nikon FM-2 with autowinder
Speed: 4.5 frames/second
Lens: 80-200mm zoom
Film: Kodak 35mm Vera Color ASA 400
- f. Photographic Still Camera
Model: Nikon MB-21 with autowinder
Speed: 5.7 frames/second
Lens: 80-200mm zoom
Film: Kodak 35mm Vera Color ASA 400

4.4.1 Test 1 Photographic Setup

The internal photographic layout (figure 4-5) for Test 1 placed one LOCAM high speed motion picture camera forward of the missile location (station 820, starboard side) and one aft (station 1320, port side). Both these cameras were set enclosed within a sand-bag barrier (figure 4-6a and b). Mirrors were used to reflect the testing imagery. To provide a second line of protection both cameras were enclosed in an environmental chamber. High intensity flash-bulbs were used to provide additional test area lighting.

The external photographic layout for Test 1 is described in figure 4-7.

4.4.2 Test 2 Photographic Setup

The photographic layout for Test 2 is described in figure 4-8.

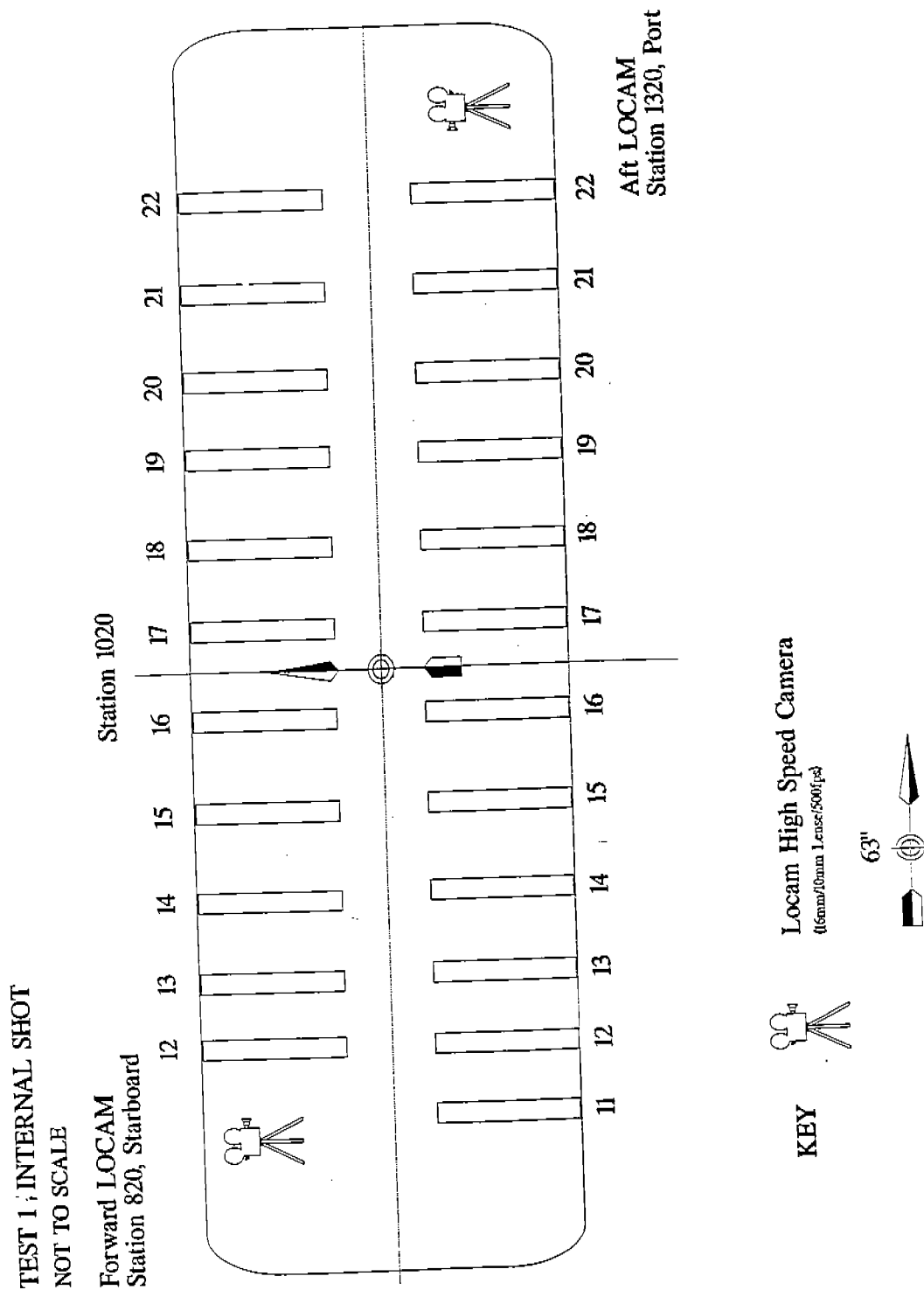


Figure 4-5 TEST 1 PHOTOGRAPHIC LAYOUT (INTERIOR)

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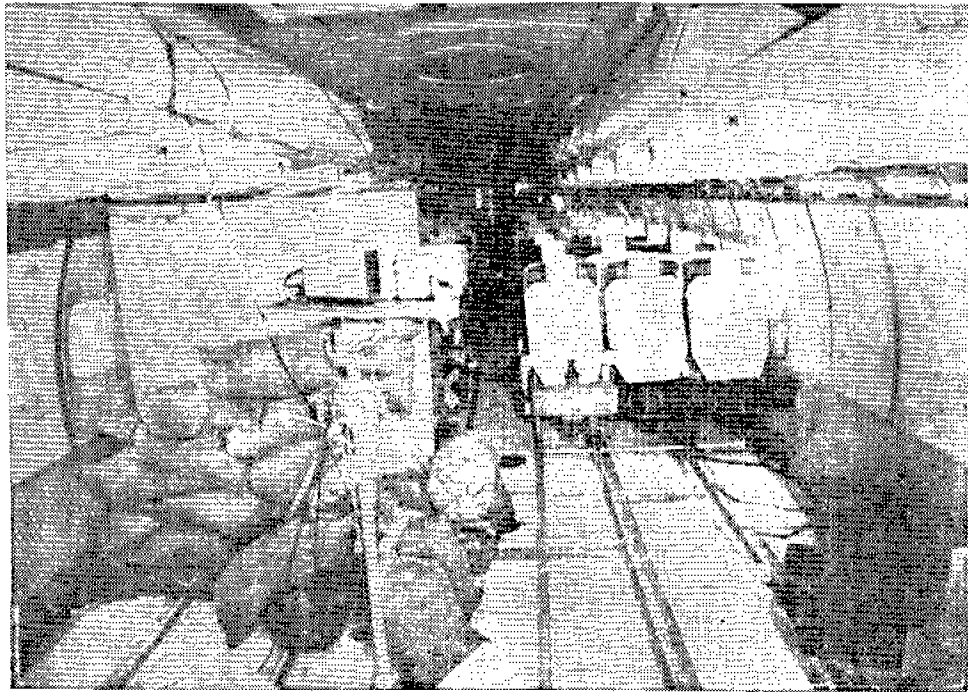


Figure 4-6a FORWARD LOCAM

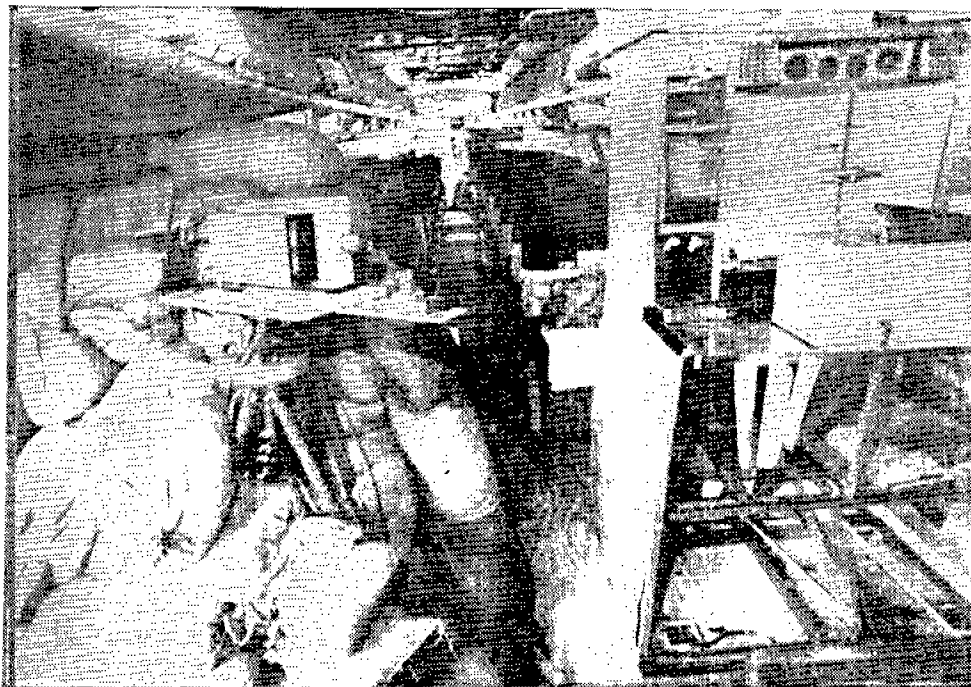


Figure 4-6b AFT LOCAM

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TEST 1 INTERNAL SHOT
NOT TO SCALE

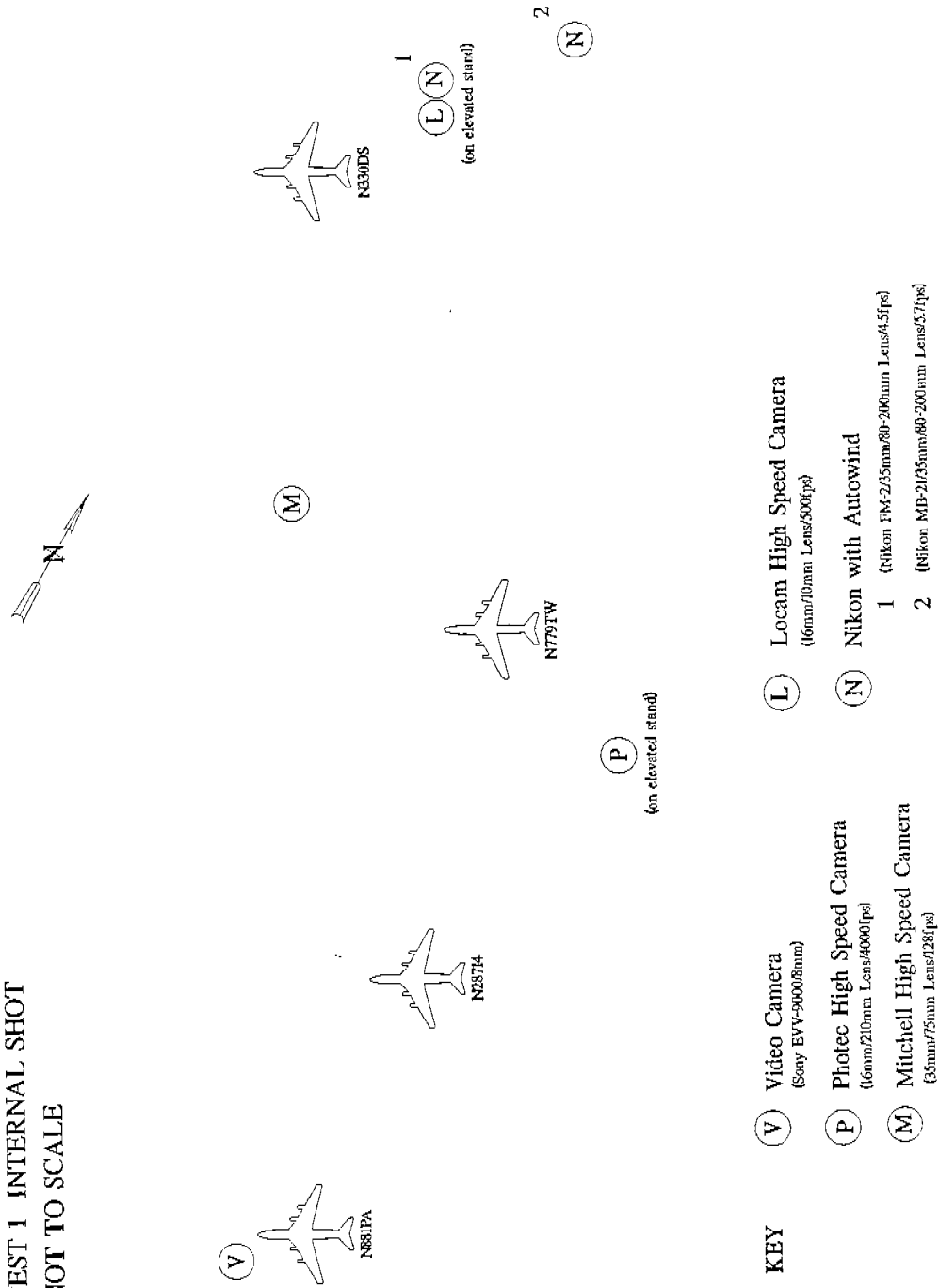


Figure 4-7 TEST 1 PHOTOGRAPHIC LAYOUT (EXTERIOR)

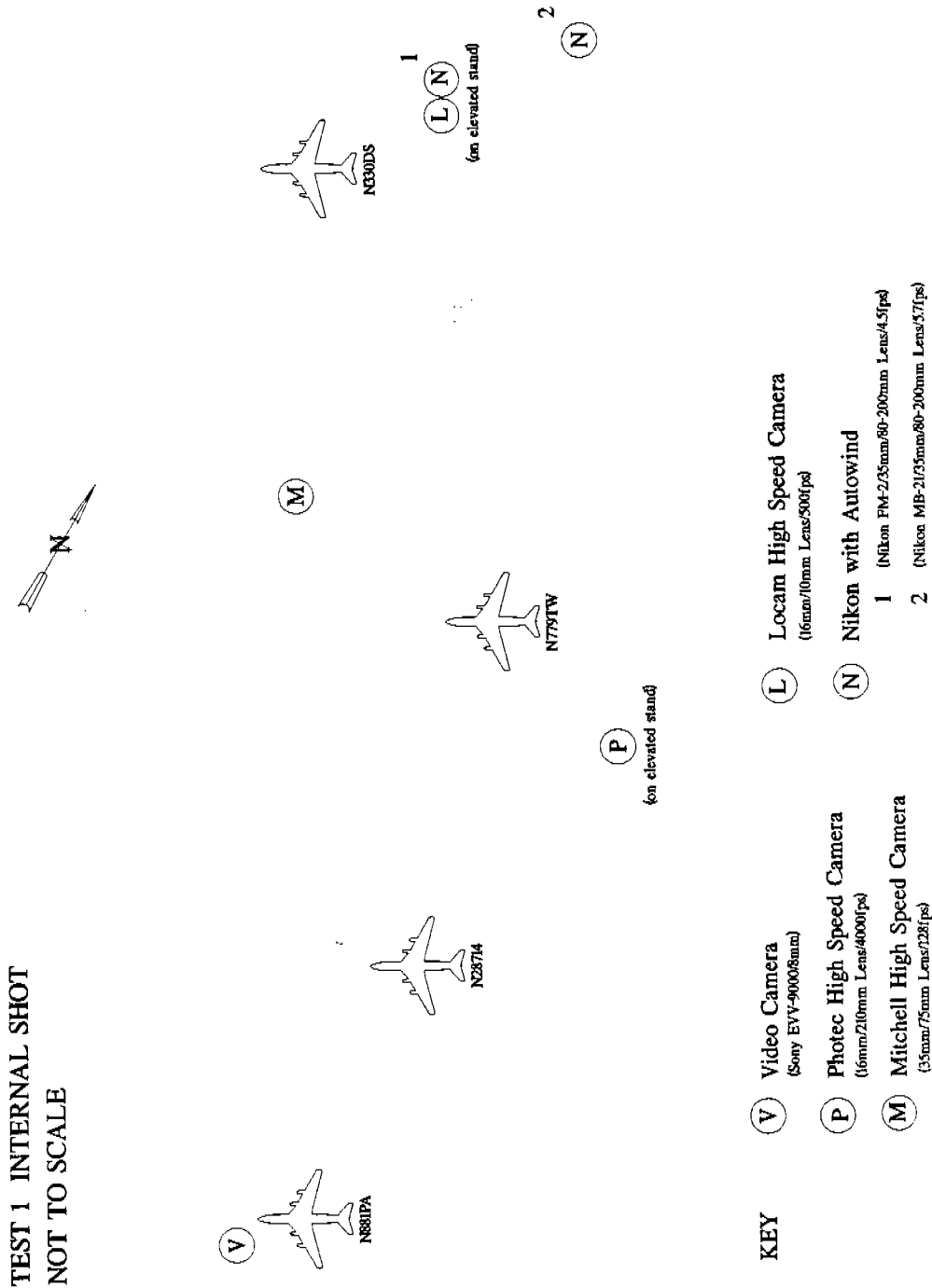


Figure 4-7 TEST 1 PHOTOGRAPHIC LAYOUT (EXTERIOR)

TEST 2 EXTERNAL SHOT
NOT TO SCALE

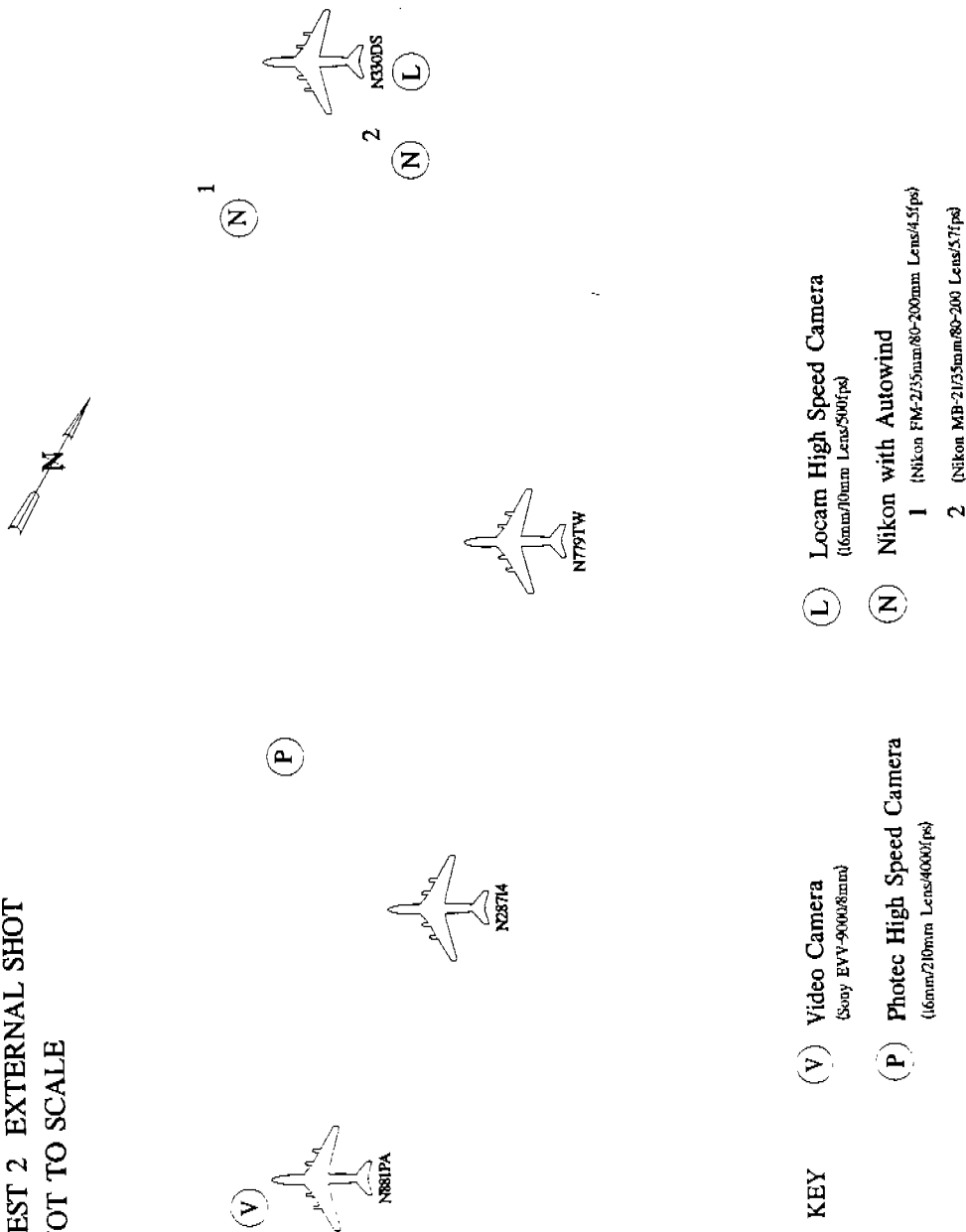


Figure 4-8 TEST 2 PHOTOGRAPHIC LAYOUT

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5.0 TEST 1 INTERNAL SHOT

5.1 Test 1 Description

The situation that is depicted in Test 1 is that of a gunner firing at a transport type aircraft where the missile tracks on the aircraft's inner port engine, and instead of impacting the engine the missile crosses through the exhaust plume and impacts the fourth body section of the aircraft, port side (figure 5-1, structural assembly section 46).

The missile was placed at station 1020, aisle 17 (figure 5-2), and 26.5 inches above the cabin floor beams, approximately level with the passenger seating (figure 5-3).

To detonate the missile a hole was drilled into the warhead section where a detonator was attached. The firing lines were connected to a system event sequencer from which all the photographic equipment was attached. When the sequencer is activated, detonation would occur after the photographic equipment was activated and running. To protect the firing lines from potential fragmentation damage they were covered with runway matting from the sequencer, which was located under aircraft N779TW, to the test aircraft (figure 4-7).

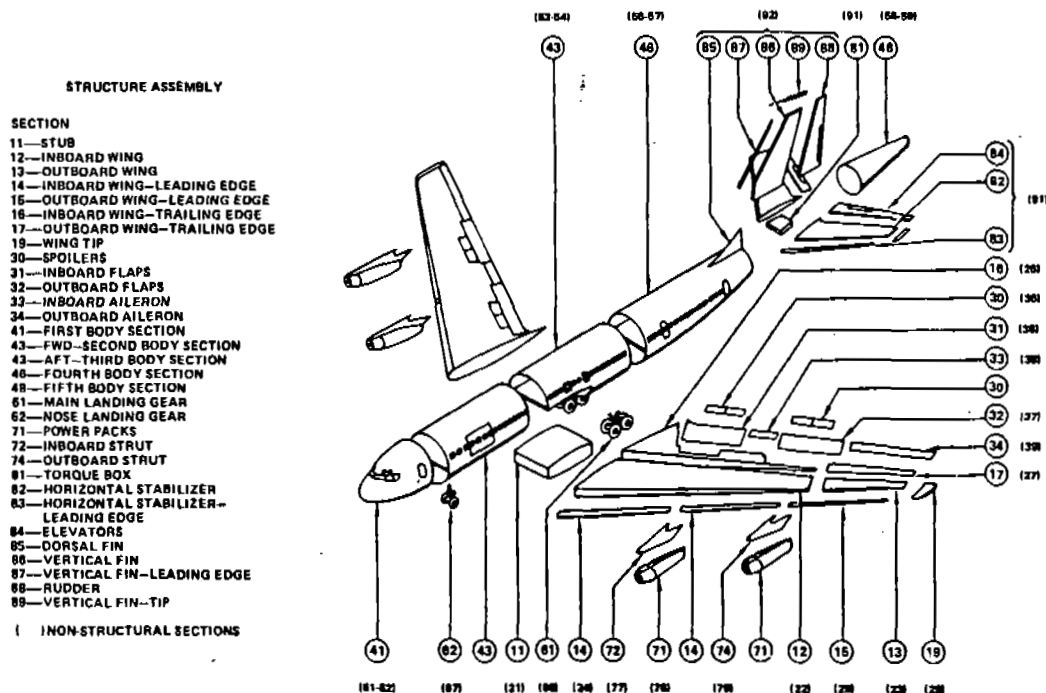


Figure 5-1 SECTION BREAKDOWN FOR BOEING 720-B

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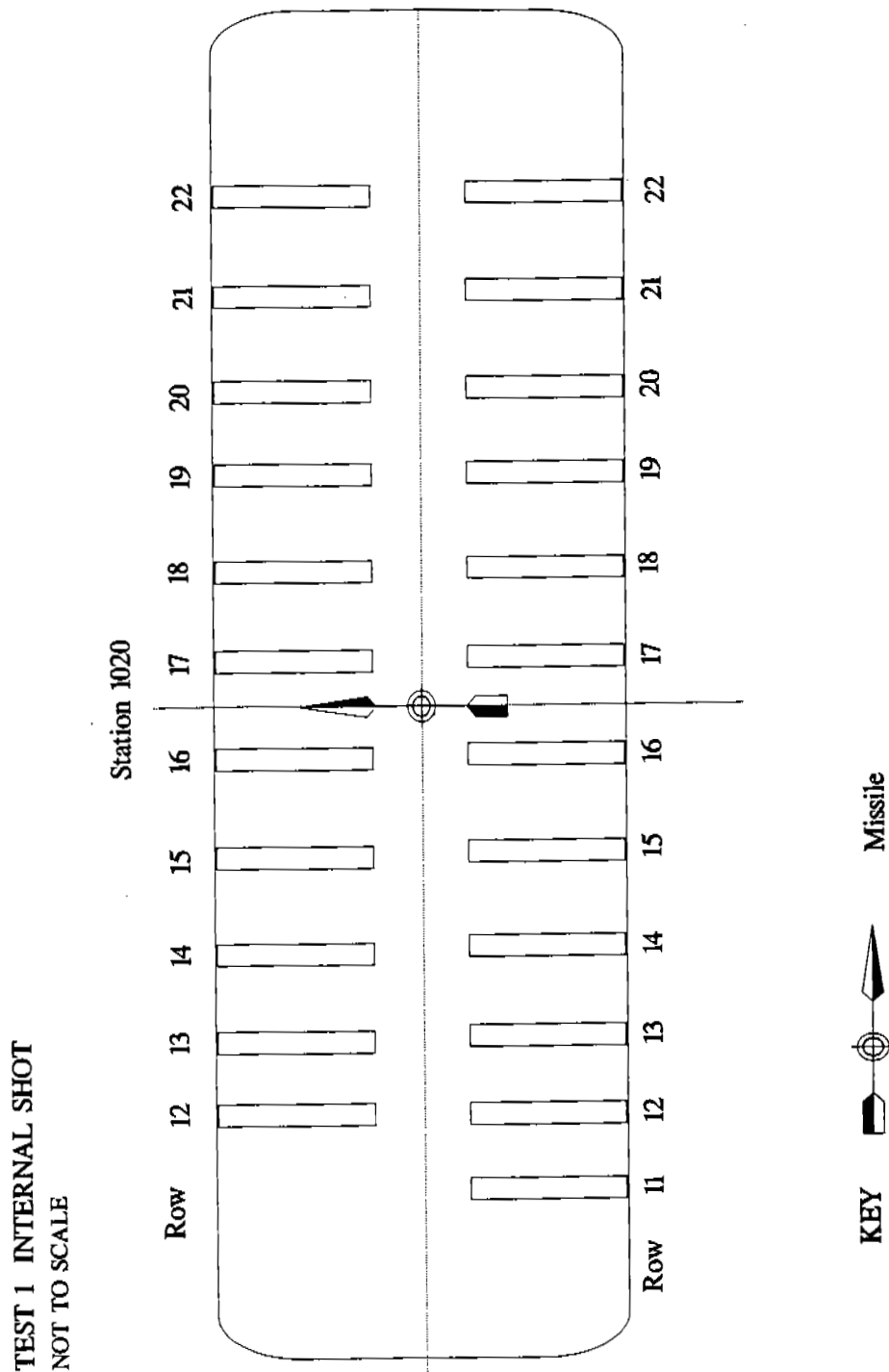


Figure 5-2 TEST 1 MISSILE PLACEMENT

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TEST 1 INTERNAL SHOT
NOT TO SCALE
STATION 1020

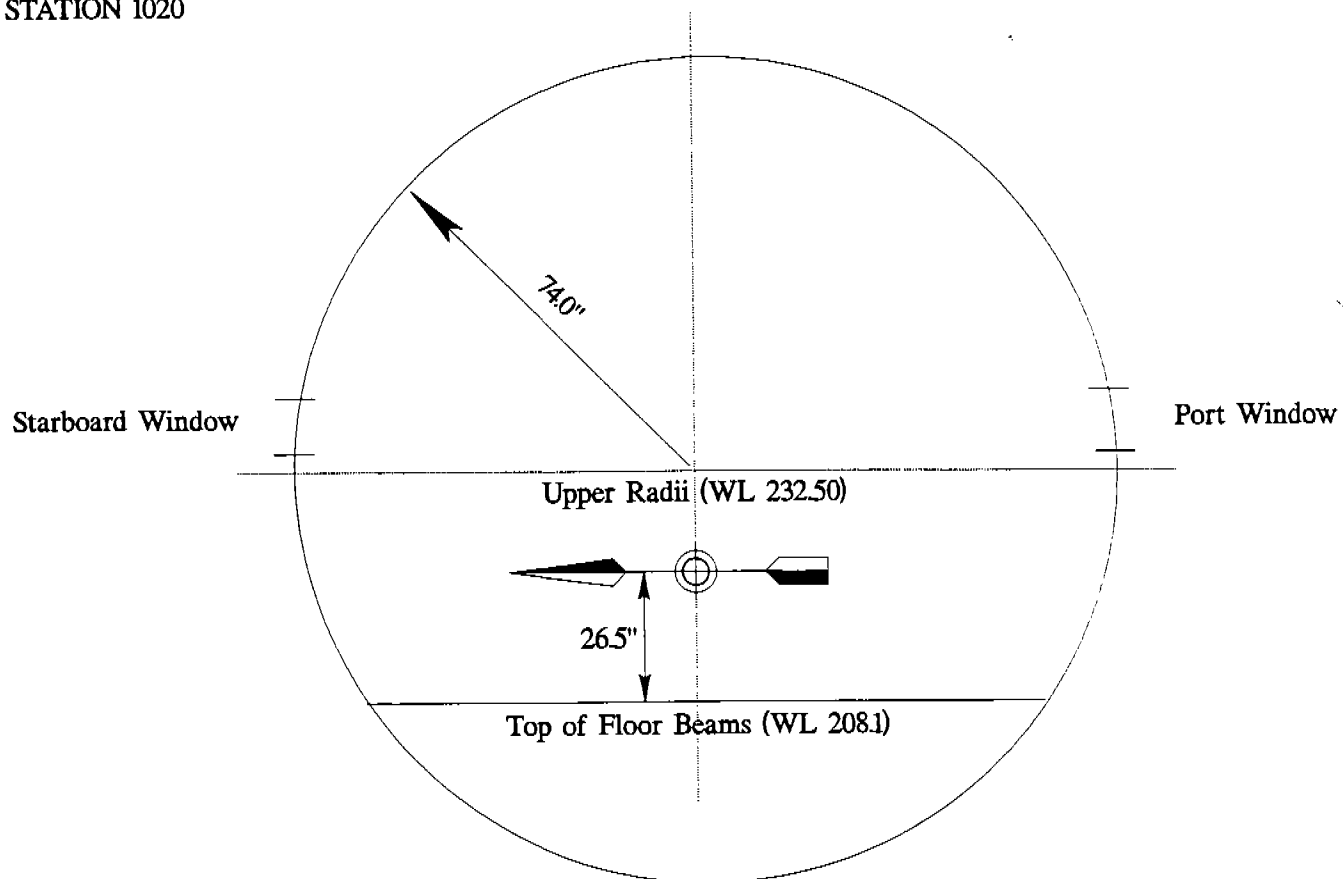


Figure 5-3 TEST 1 MISSILE PLACEMENT

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5.2 Test 1 Sequence

Test 1 was conducted on August 25 (attempts 1&2) and 26 (attempt 3), 1993.

5.2.1 Test 1 Attempt 1

The prevailing atmospheric conditions during this test included the following:

- a) Wind: Minimal (0-5 knots)
- b) Clouds: Overcast
- c) Temperature: 80-85°F

The charge was set and the area was cleared twice by the range safety officer. All personnel were cleared away from the aircraft and the road closed off to all traffic.

The time sequence for Test 1, attempt 1, was the following (all times are in mountain standard time):

- 12:28 PM: Missile and detonator hooked up.
- 12:30 PM: System event sequencer hooked up.
- 12:33 PM: System event sequencer activated with no detonation.
- 12:34 PM: System event sequencer activated for second time with no detonation.
- 12:35 PM: System event sequencer disconnected.
- 12:37 PM: Range safety officer disconnects detonator from warhead rendering missile safe.
- 12:40 PM: Weapon is cleared from test site.

After trouble shooting the firing lines and sequencer it was determined that a faulty relay within the system event sequencer was the cause for the weapon misfire. A new relay was subsequently installed and the circuit tested.

In addition to the faulty relay, the Mitchell high speed motion picture camera was damaged. A possible reason for this failure may have been due to the gas powered generator producing electrical surges resulting in a subsequent surge on the Mitchell's high speed motor and shutter.

5.2.2 Test 1 Attempt 2

The prevailing atmospheric conditions during this test included the following:

- a) Wind: SW (15-20 knots)
- b) Clouds: Overcast
- c) Temperature: 75-80°F

The charge was set and the area was cleared twice by the range safety officer. All personnel were cleared away from the aircraft and the road closed off to all traffic.

The time sequence for Test 1, attempt 2, was the following (all times are in mountain standard time):

- 1:58 PM: Missile and detonator hooked up.

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2:01 PM: System event sequencer hooked up.

2:05 PM: System event sequencer activated with no detonation.

2:06 PM: System event sequencer activated for second time with no detonation.

2:08 PM: System event sequencer disconnected.

2:13 PM: Range safety officer disconnects detonator from warhead rendering missile safe.

2:17 PM: Weapon is cleared from test site.

After diagnosing the firing lines and generator it was determined that because the generator was not producing a constant output the firing circuit did not fire. To correct this problem the generator was replaced.

5.2.3 Test 1 Attempt 3

The prevailing atmospheric conditions during this test included the following:

- a) Wind: SW (5-10 knots)
- b) Clouds: Overcast
- c) Temperature: 80-85°F

The charge was set and the area was cleared twice by the range safety officer. All personnel were cleared away from the aircraft and the road closed off to all traffic.

The time sequence for Test 1, attempt 3, was the following (all times are in mountain standard time):

10:28 AM: Missile and detonator hooked up.

10:33 AM: System event sequencer hooked up.

10:37 AM: System event sequencer activated with detonation.

10:38 AM: Dark smoke observed from test aircraft.

10:40 AM: Obvious fire observed from aircraft. DMAFB fire rescue called in. Test personnel attempt to put out fire in early stage.

10:42 AM: Flames have engulfed the aft third body section and fourth body section of the aircraft (figure 5-1). For safety reasons test personnel give up attempt to control fire.

10:50 AM: Top side of fuselage is completely burned through with flames still burning towards the tail.

10:52 AM: DMAFB fire rescue arrives.

10:59 AM: Additional water called in to fight fire.

12:15 AM: Fire is secured and remnants of test aircraft are safe to approach.

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5.3 Test 1 Damage

It was apparent that the significant damage mechanisms were a combination of fragmentation and fire.

5.3.1 General Fragmentation Damage

After observing high speed photography it was apparent that upon detonation multiple fragments were seen piercing and departing the aircraft. There was little observable underside fragmentation damage.

Due to the subsequent fire damage (which resulted in the majority of the aircraft's fuselage skin being burned away, several burn-throughs, and deformation) it was impossible to ascertain the actual fragmentation damage.

The cable junctions under the floor boards were damaged severely.

A significant loss of life would result from the fragmentation alone.

5.3.2 General Fire Damage

The vast majority of damage inflicted on the test aircraft was a result of fire.

The most likely cause of fire is a combination of the initial detonation fire-ball and high velocity metal fragmentation impacting the metal surfaces of the aircraft structure and igniting the interior.

The fire initially started in the location where the missile was stationed. Almost immediately the surrounding area within the cabin ignited spreading the flames forward of the aft third body section and aft to the fourth body section of the aircraft. As indicated in the chronology in section 5.2.3 it took less than three minutes for a significant fire to develop and less than five minutes before the aircraft was engulfed in flames.

Figures 5-4a, 5-4b, 5-4c, and 5-4d portrays the severity of the flame that occurred after detonation. Figure 5-5a and 5-5b portrays the exterior of the aircraft after it was extinguished. The aircraft before detonation is portrayed in figure 4-3.

Upon inspection, the interior from station 600-J aft was completely gutted (figure 5-6a and 5-6b). The interior before detonation is portrayed in figure 4-4.

5.4 Damage Summary

For the purpose of this test it must be understood that though fire played a key role in the damage process; in a real situation, fragmentation would be the key damage process for a missile fired in these parameters.

In reality a fire of this nature would not likely be experienced if the aircraft was airborne. As discussed in section 4.2 the aircraft was missing the entire skin surface and associated structures from station 420 to 600-J, and from the top of the floor beam (WL 208.1) up. In addition, the prevailing wind conditions maintained a constant 5 to 10 knot headwind allowing a steady stream of air to be funneled into an already hot fire source, thus feeding it and allowing it to spread.

FUTURE TEST RECOMMENDATION: While on the test site ensure that there is at least a portable water-based fire fighting unit at the test site.

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FUTURE TEST RECOMMENDATION: An emergency fire and medical team should be on the test site during weapons detonation and an adequate first aid kit on the site at all times.

An aircraft interior provides ample fuel for any fire.

The most significant fire threat would come from a fragment penetrating the fuel or hydraulic system and igniting it.

Though the aircraft was practically rendered useless in providing forensic data relating to fragmentation damage, the following can be deduced:

- a) High-speed photography documented multiple (if not hundreds) of fragments exiting the aircraft.
- b) Major structural damage occurred. This included skin, stringer, and frame damage as a result of blast and fragmentation.
- c) Though the missile was stationed inside the aircraft, in reality a missile impacting an aircraft would cause massive damage in itself.
- d) Multiple cables, which run under the floor beam would be damaged resulting in a loss or degradation of control actuators and flight control surfaces. In this case the elevator and rudder control, and trim (vertical and lateral) would be damaged or degraded. In addition, depending on how far forward the fragmentation pattern extended the ailerons (inboard and outboard), spoilers (inboard and outboard), flaps (inboard and outboard), leading edge flaps, and trim (longitudinal) control could be damaged or degraded.
- e) Systems damage would occur in the utility hydraulics system controlling the main landing gear and brakes. In addition, depending on how far forward the fragmentation pattern extended the primary and auxiliary hydraulic systems controlling all flight controls systems could be damaged or degraded.
- f) The center fuel tank was damaged. This cell is the largest out of seven in the system and holds approximately 68 thousand pounds of fuel.



Figure 5-4a FIRE VIEWED FROM PORT SIDE



Figure 5-4b FIRE VIEWED FROM STARBOARD SIDE

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Figure 5-4c FIRE VIEWED FROM STARBOARD SIDE (CLOSE-UP)



Figure 5-4d FIRE VIEWED FROM STARBOARD SIDE (CLOSE-UP)

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Figure 5-5a STARBOARD SIDE AFTER FIRE

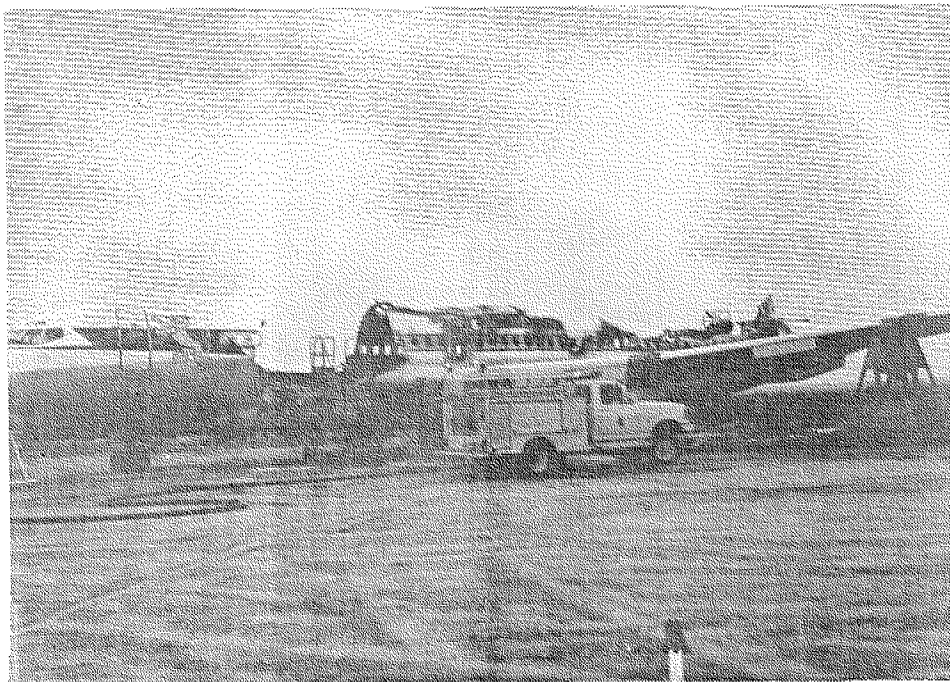


Figure 5-5b PORT SIDE AFTER FIRE

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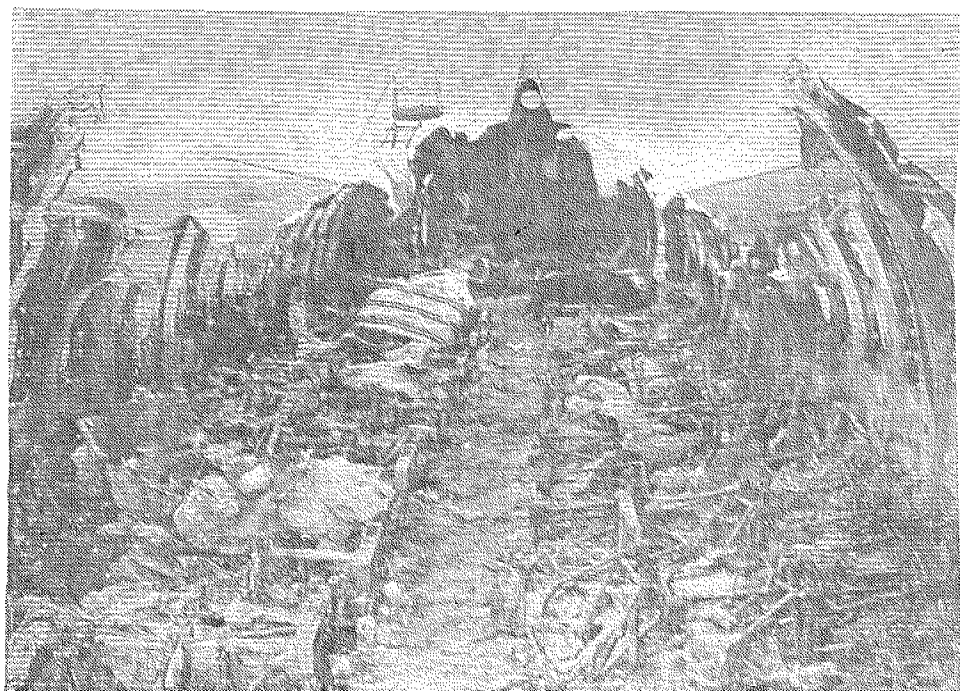


Figure 5-6a INTERIOR LOOKING AFT AFTER FIRE



Figure 5-6b INTERIOR LOOKING FORWARD AFTER FIRE

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6.0 TEST 2 EXTERNAL SHOT

6.1 Test 2 Description

The situation depicted in Test 2 is that of a gunner firing at a transport type aircraft where the missile tracks on the aircraft's inner port engine and detonates when it impacts the engine compartment (figure 5-1, inboard strut and power pack).

The missile was placed 50 inches below the port inboard strut location and 45 inches above the ground (figure 6-1).

**TEST 2 EXTERNAL SHOT
NOT TO SCALE**

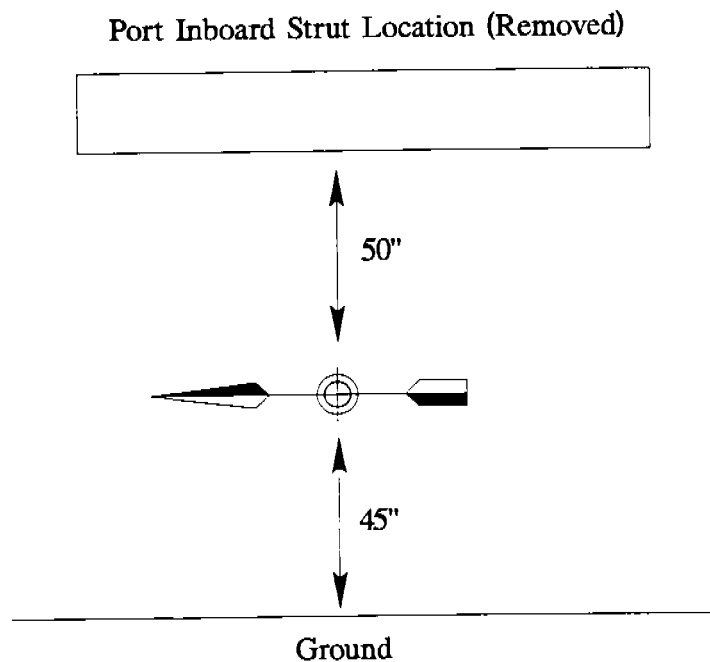


Figure 6-1 TEST 2 MISSILE PLACEMENT

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To investigate the effect of a missile detonation to fuel cells, the port fuel cells were filled with water.

To detonate the missile a hole was drilled into the warhead section where a detonator could be attached. The firing lines were connected to a system event sequencer from which all the photographic equipment was attached. When the sequencer is activated detonation would occur after the photographic equipment was activated and running. To protect the firing lines from potential fragmentation damage they were covered with runway matting from the sequencer, which was located under aircraft N779TW, to the test aircraft (figure 4-8).

6.2 Test 2 Sequence

Test 2 was conducted on August 26, 1993.

6.2.1 Test 2

The prevailing atmospheric conditions during this test included the following:

- a) Wind: SW (5-10 knots)
- b) Clouds: Overcast
- c) Temperature: 75-80°F

The charge was set and the area was cleared twice by the range safety officer. All personnel were cleared away from the aircraft and the road closed off to all traffic.

The time sequence for Test 2 was the following (all times are in mountain standard time):

2:18 PM: Missile and detonator hooked up.

2:23 PM: System event sequencer hooked up.

2:26 PM: System event sequencer activated with detonation.

6.3 Test 2 Damage

The significant damage mechanisms experienced in this test were fragmentation and blast.

6.3.1 General Blast Damage

A panel used to access the port main landing gear, located on the port upper-wing (approximately wing station 274, trailing edge), was jarred loose. See figure 6-2.

The port inboard dry bay access panel was blown completely off (approximate wing station 387, adjacent to leading edge flap number 3). See figure 6-2.

The port inboard fueling dry bay access panel was blown open but not completely off (approximately wing station 529, adjacent to leading edge flap number 2). See figure 6-2.

6.3.2 General Fragmentation Damage

After observing high speed photography it was apparent that upon detonation multiple fragments pierced the aircraft's under-side port wing. No fragments were seen piercing the upper-side of the port wing.



Figure 6-2 WING CENTERLINE DIAGRAM FOR BOEING 720-B

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The majority of fragmentation piercing was observed to be as little as small dents to large holes as big as five centimeters (the average was .25 to .75 centimeters). Three holes were as large as eight centimeters.

Due to the location of the wing support pylon (refer section 4.2), fragmentation damage past the port inboard strut location was minimal. However, the wing support pylon was peppered with fragmentation damage.

6.3.2.1 Specific Fragmentation Damage

Fragmentation damage was broken into two specific types:

- * Maximum Fragmentation Damage
- * Minimum Fragmentation Damage

6.3.2.1.1 Maximum Fragmentation Damage

The vast concentration of damage was immediately centralized to where the missile was placed (figure 6-3). This area ranged from the wing root to the wing support pylon (approximately wing station 643).

TEST 2 EXTERNAL SHOT
NOT TO SCALE

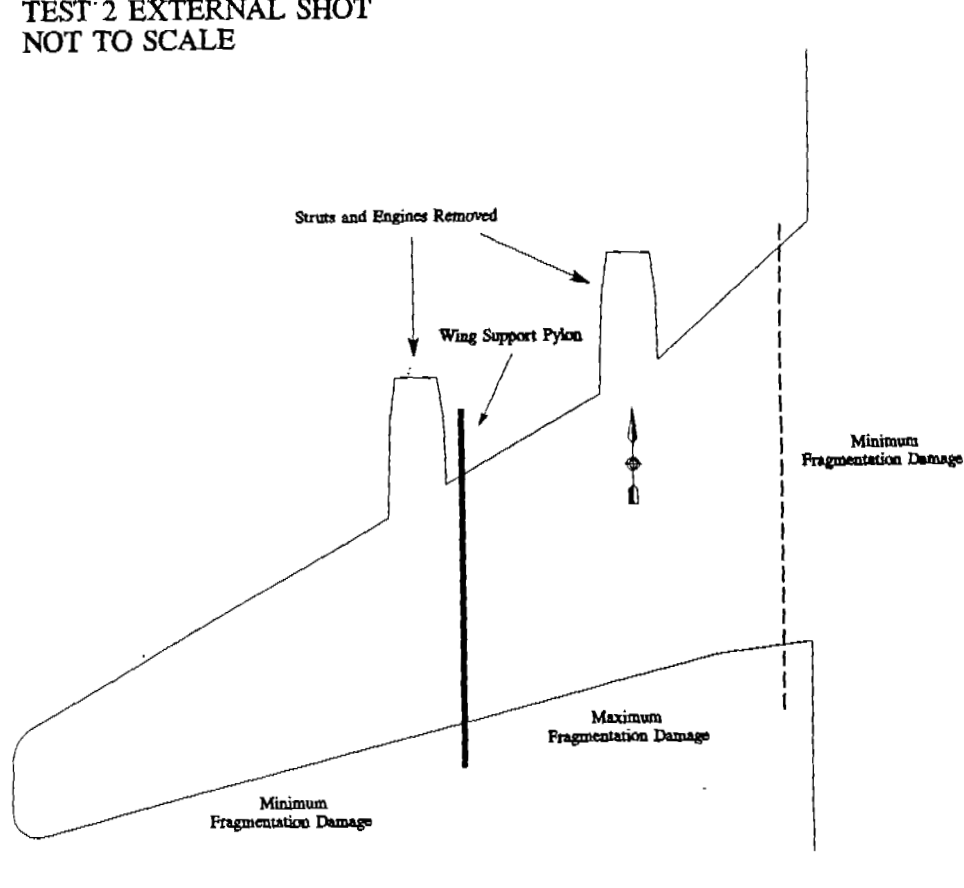


Figure 6-3 FRAGMENTATION DAMAGE

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Fragmentation ranged from small particles causing airframe scratches to fragments producing holes with a diameter of eight centimeters.

All forms of ballistic penetration occurred ranging from plugging and punching, being the majority, (figure 6-4) to petalling (figure 6-5a, 6-5b, and 6-5c).

The average size of significant fragmentation damage ranged from .25 to .75 centimeters.

6.3.2.1.2 Minimum Fragmentation Damage

The areas in which minimum observable damage occurred was past the wing support pylon (wing station 643 outboard) and the wing root inboard to the fuselage.

The majority of the damage was airframe scratches; However, there were some holes that penetrated through the airframe.

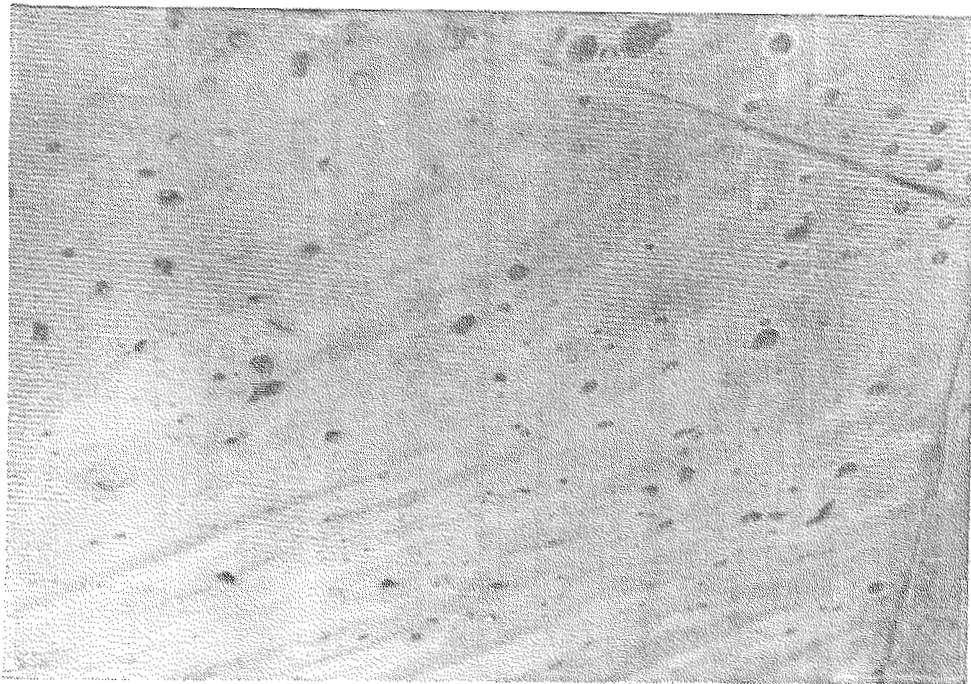


Figure 6-4 PLUGGING OR PUNCHING DAMAGE

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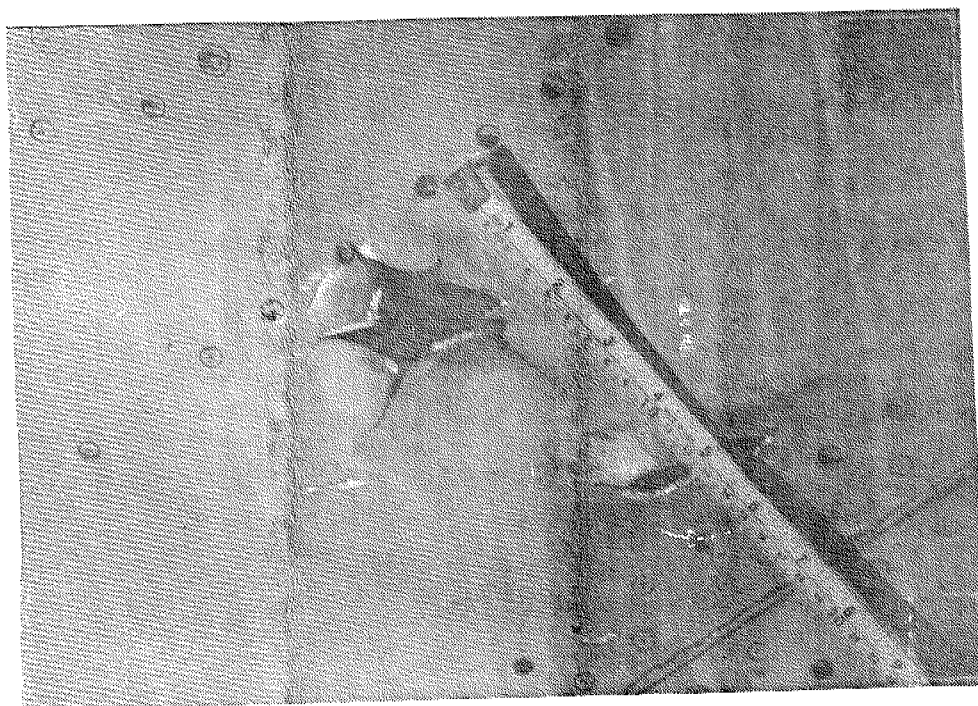


Figure 6-5a PETALLING DAMAGE

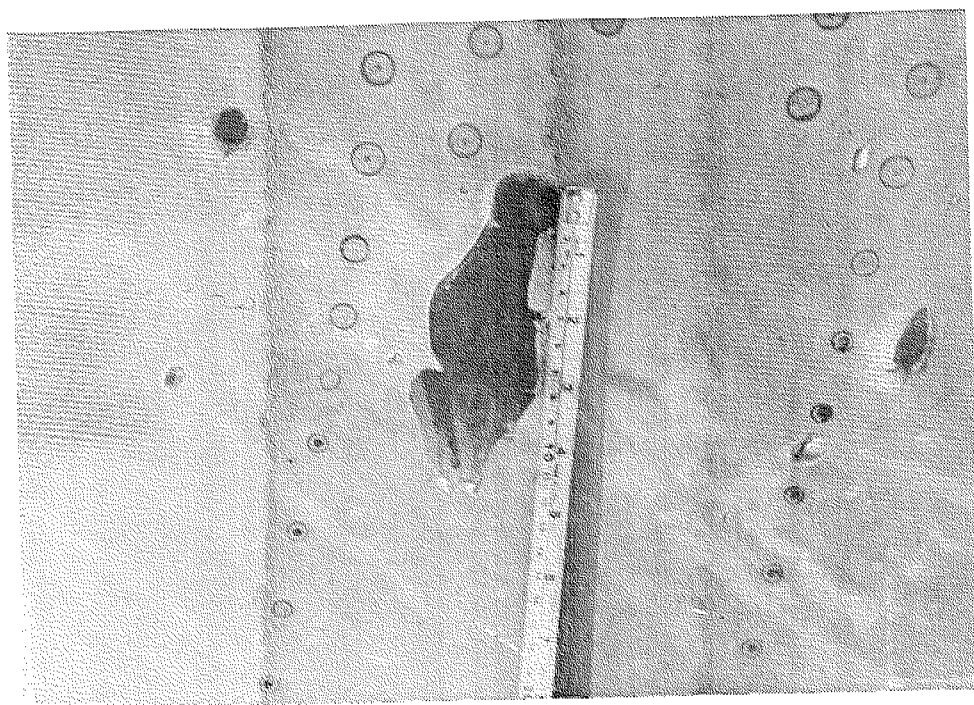


Figure 6-5b PETALLING DAMAGE

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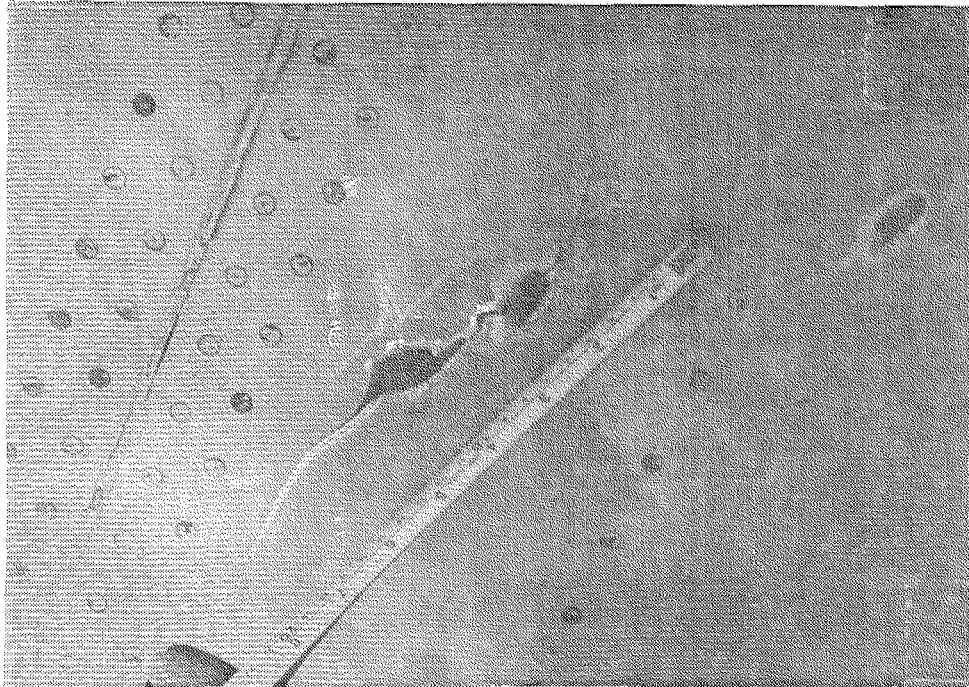


Figure 6-5c PETALLING DAMAGE

6.4 Damage Summary

Immediately after detonation of the missile it was apparent that the port inboard engine would be fatally damaged and the port outboard engine would likely be damaged to a lesser degree. In either case missile fragments entering both engine compartments, particularly the port inboard engine, where the missile detonated, would FOD out the engines and likely cause secondary FOD damage to other aircraft components and systems (refer to section 2.1.1.1).

All engine driven components of the port inboard and possibly outboard engine would be damaged (i.e., generators, fuel pumps, hydraulic fluid pumps, etc.).

The most serious damage would be inflicted on the aircraft's fuel tank system (figure 6-6). After the blast the center tank (68 thousand pounds of fuel), main tank number two (27 thousand pounds), and main tank number one (16 thousand pounds) were riddled with fragmentation damage (figure 6-7a and 6-7b) allowing water (simulated fuel) to spill out. An aircraft hit in these areas would likely ignite into an uncontrollable fire despite any quick response by the flight crew.

As a result of fragmentation the following aircraft control surfaces and related actuators would likely be damaged (figure 6-8):

- a) Port Leading Edge Flaps (physical fragmentation damage)
- b) Port Fillet Flap (physical fragmentation damage)
- c) Port Inboard Spoiler
- d) Port Inboard Flap (physical fragmentation damage)
- e) Port Inboard Aileron (physical fragmentation damage)

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- f) Port Inboard Aileron Control Tab
- g) Port Outboard Spoiler
- h) Port Outboard Flap (physical fragmentation damage)

The port main landing gear would be damaged.

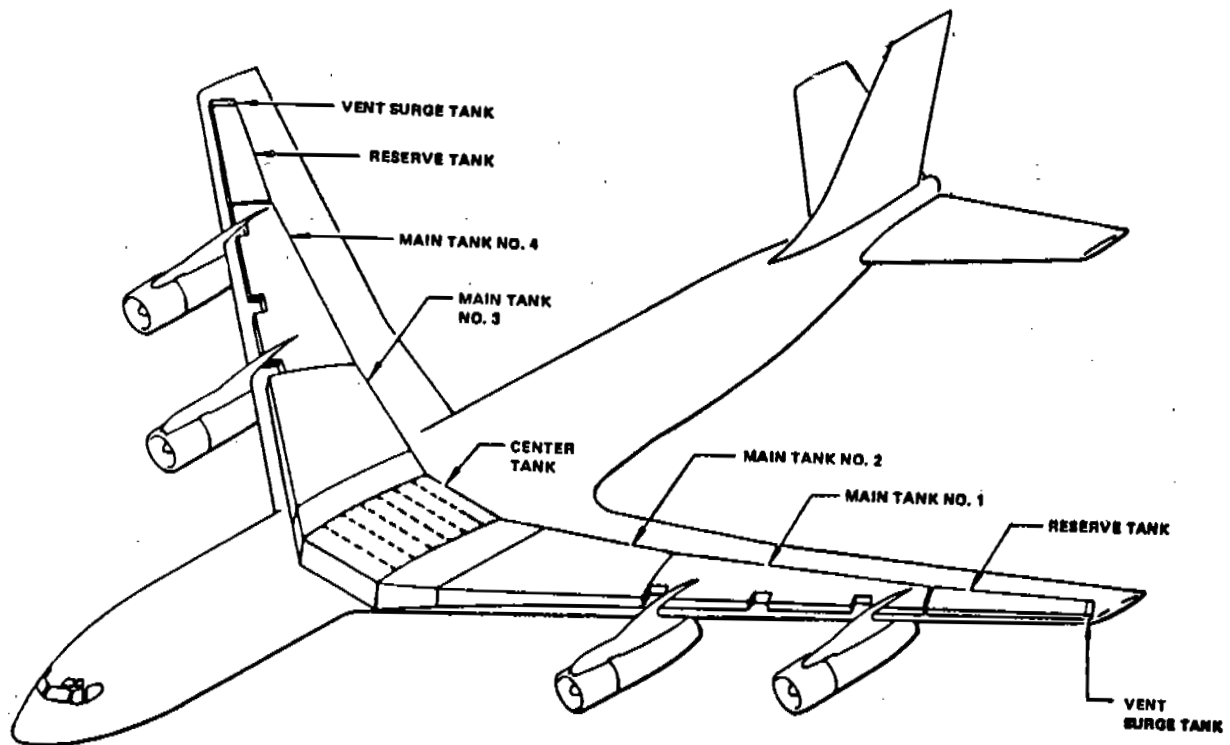


Figure 6-6 FUEL TANK ARRANGEMENT FOR BOEING 720-B

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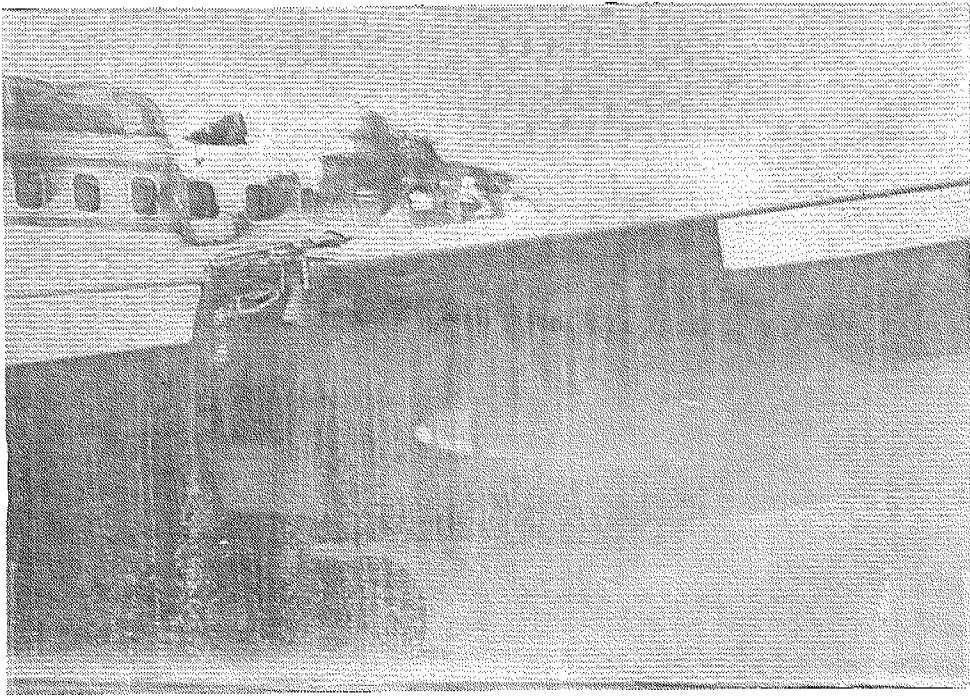


Figure 6-7a SIMULATED FUEL SPILL IMMEDIATELY AFTER BLAST

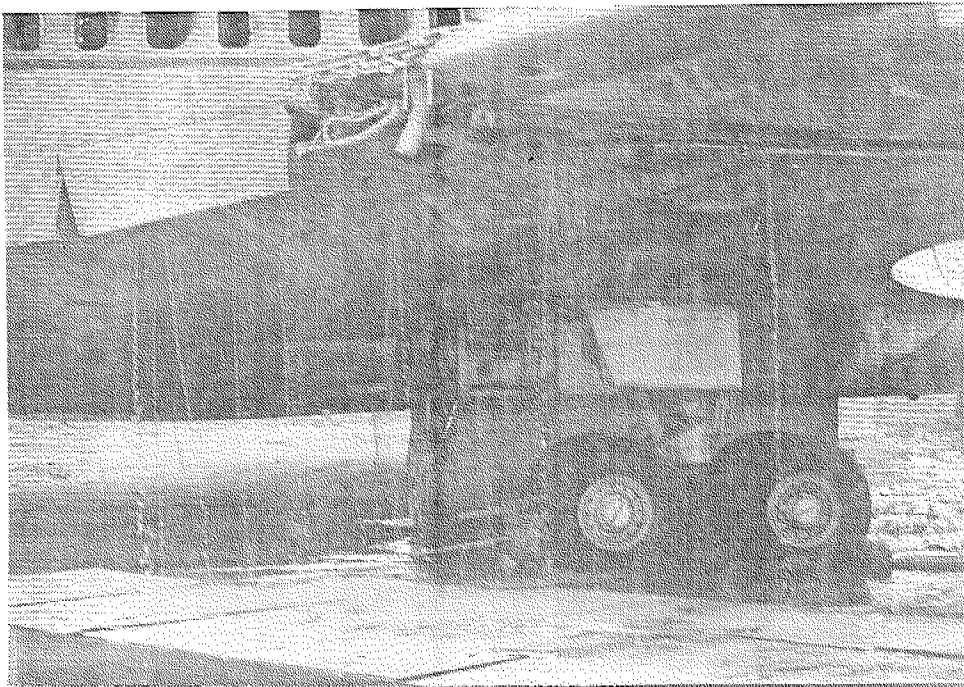


Figure 6-7b SIMULATED FUEL SPILL SHORTLY AFTER BLAST

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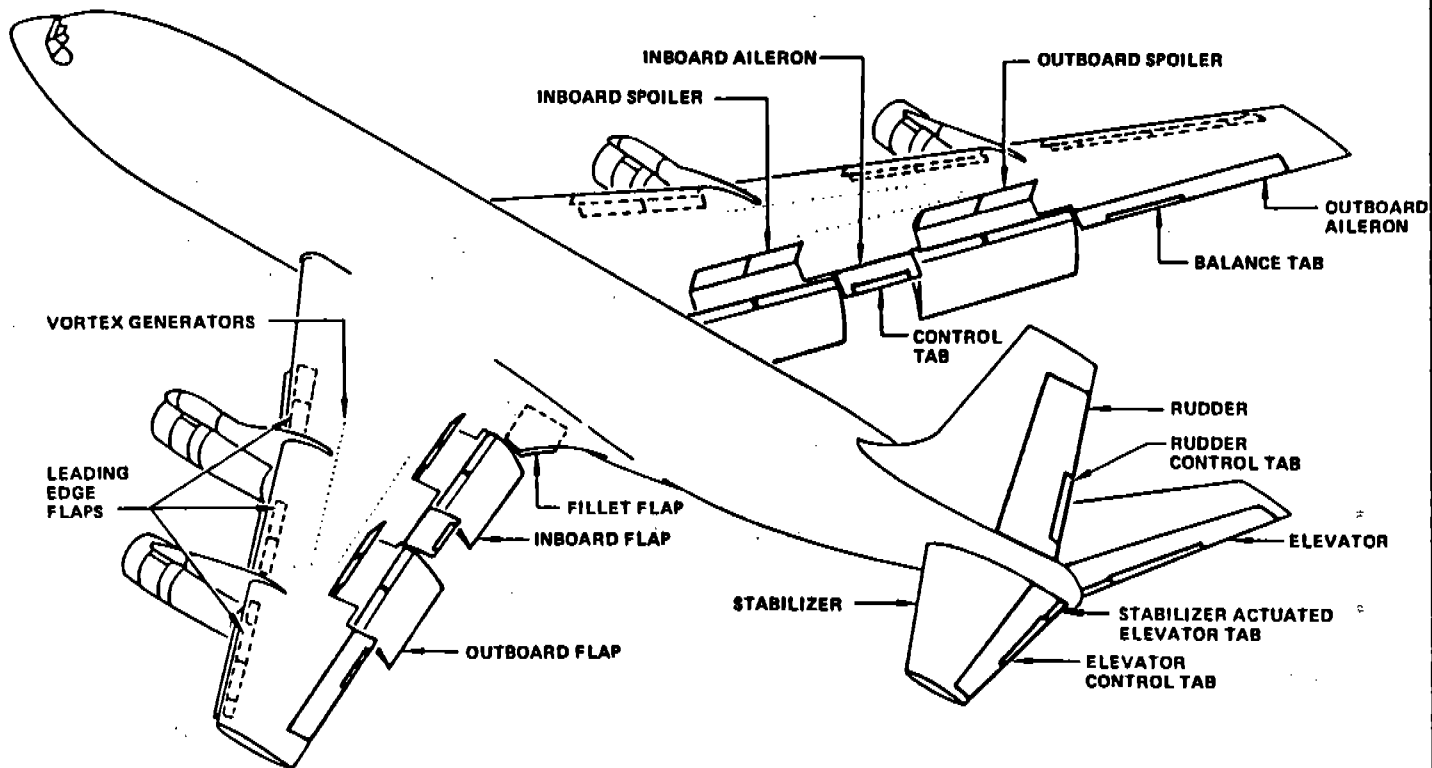


Figure 6-8 CONTROL SURFACES FOR BOEING 720-B

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7.0 CONCLUSION

7.1 Test Discoveries

An aircraft being hit in the same areas as Test 1 would likely crash immediately as a result of control cable damage and failure (section 5.3 and 5.4).

An aircraft being hit in the same areas as Test 2 would likely crash as a result of uncontrollable fire (section 6.3 and 6.4). A very quick response from the flight crew might allow a controlled landing.

7.2 Threat

Various forms of MANPADS are proliferated worldwide (including terrorist factions).

7.3 Vulnerability

These portable missile systems, though most effective with low altitude aircraft, can be effective at a range of 7000 meters (22,967 feet) and an altitude of 6900 meters (22,639 feet) depending on the system utilized.

Though the system would be most effective against a landing or taking off commercial transport, some missile system effective envelopes will allow an adequate firing solution outside the airport confines and security jurisdictions.

Published Standard Terminal Arrivals (STARs), Standard Instrument Departures (SIDs), and Standard Instrument Approach Procedures (SIAPs) and related navigation publications will allow any gunner to easily prepare and plan a launch position (figure 7-1, 7-2, 7-3, 7-4, and 7-5). All U.S. Terminal Procedures are written in feet.

UNITED STATES GOVERNMENT FLIGHT INFORMATION PUBLICATION

U.S. TERMINAL PROCEDURES

NORTHEAST (NE) VOL. 3 OF 3

INSTRUMENT APPROACH PROCEDURES • STANDARD TERMINAL ARRIVALS

STANDARD INSTRUMENT DEPARTURES • AIRPORT DIAGRAM

EFFECTIVE: 0901Z: **4 FEB 1993**

TO: 0901Z: **1 APR 1993** Consult NOTAMs for latest information

CONSULT CHANGE NOTICE (CN) EFFECTIVE 4 MAR 1993 FOR INTERIM UPDATE

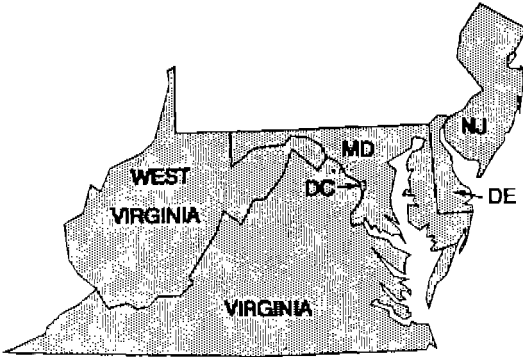



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National Ocean Service

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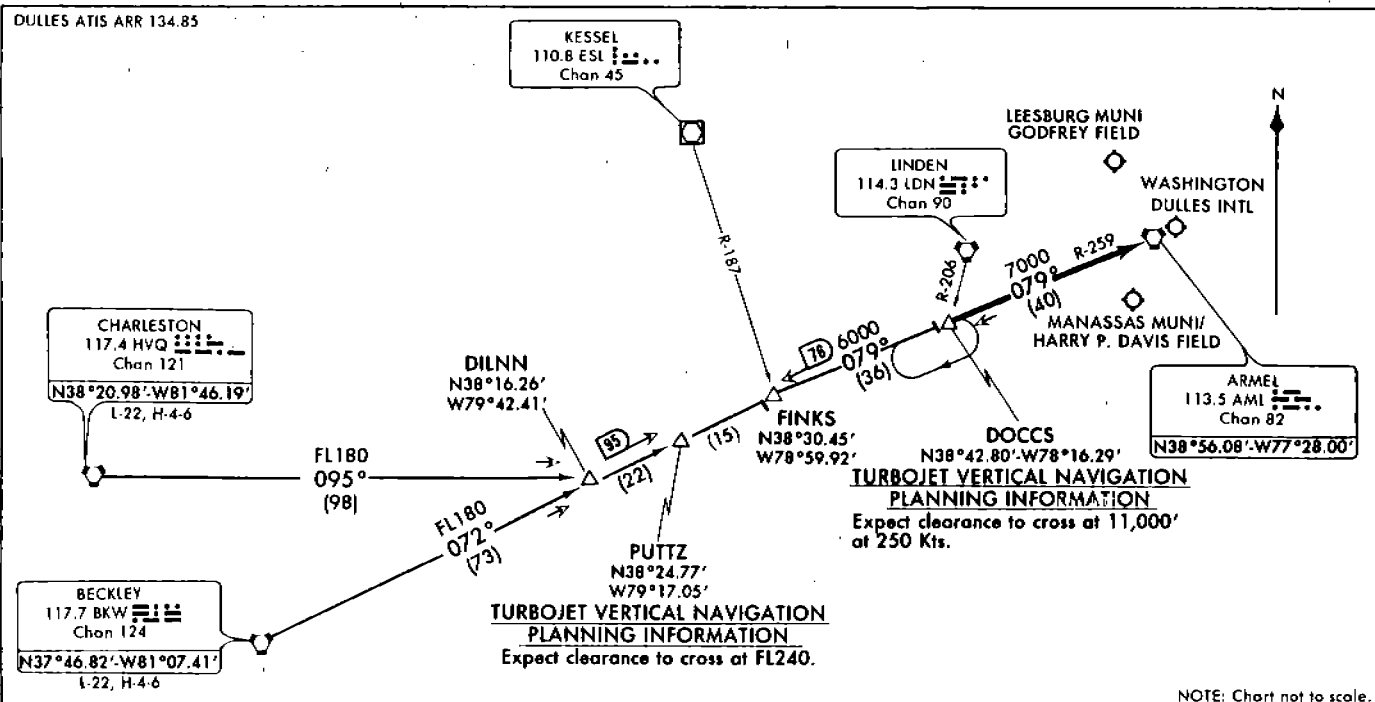
Figure 7-1 PUBLISHED U.S. TERMINAL PROCEDURES

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92289
DOCCS FOUR ARRIVAL (DOCCS.DOCCS4)

ST-5100 (FAA)

WASHINGTON, DC



BECKLEY TRANSITION (BKW.DOCCS4): From over BKW VORTAC via BKW R-072 and AML R-259 to DOCCS INT. Thence

CHARLESTON TRANSITION (HVQ.DOCCS4): From over HVQ VORTAC via HVQ R-095, BKW R-072 and AML R-259 to DOCCS INT. Thence

. . . . From over DOCCS INT via AML R-259 to AML VORTAC. Expect radar vectors to final approach course after AML VORTAC.

DOCCS FOUR ARRIVAL (DOCCS.DOCCS4)

P5

WASHINGTON, DC

Figure 7-2 PUBLISHED STANDARD TERMINAL ARRIVAL (STAR)

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7-3

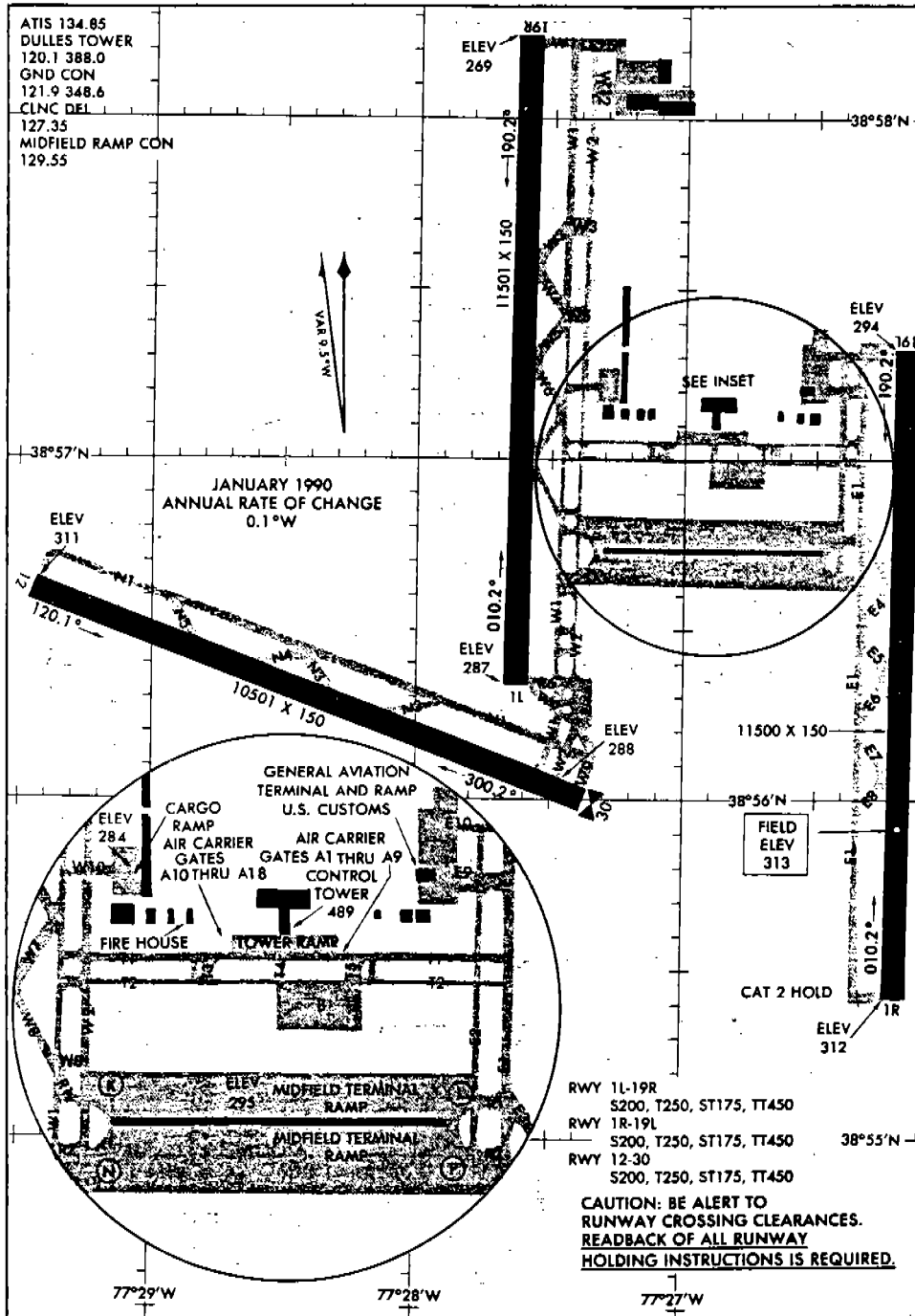
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92345

AIRPORT DIAGRAM

AL-5100 (FAA)

WASHINGTON DULLES INTL (IAD)
WASHINGTON, D.C.



AIRPORT DIAGRAM

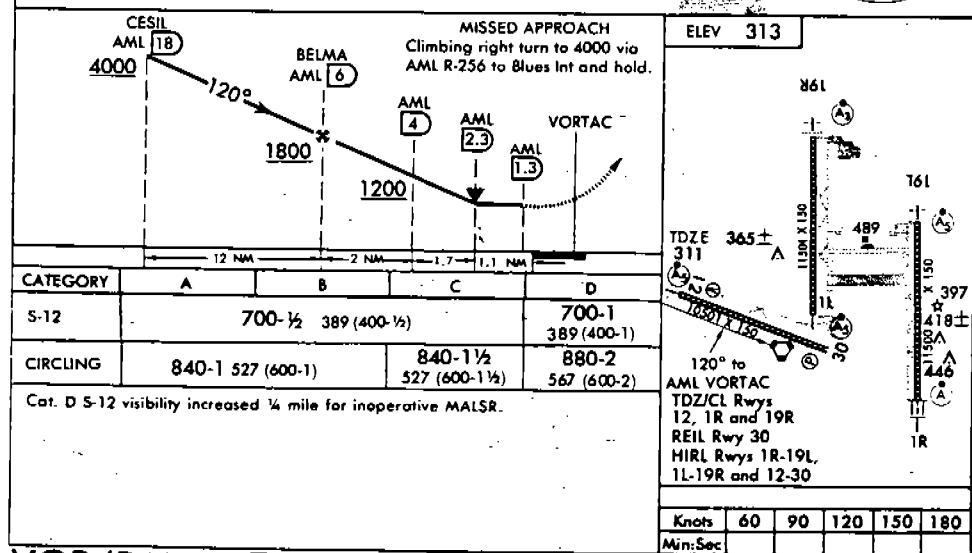
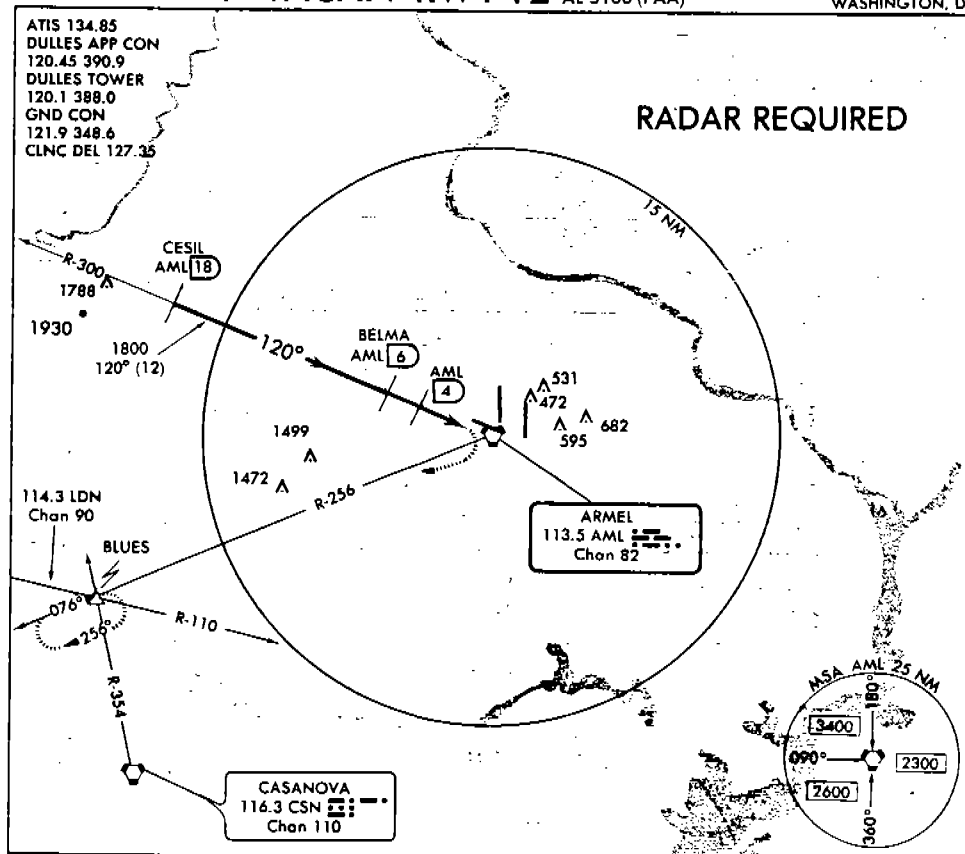
WASHINGTON, D.C.
WASHINGTON DULLES INTL (IAD)

315

Figure 7-3 PUBLISHED AIRPORT DIAGRAM

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Amdt 7 93035

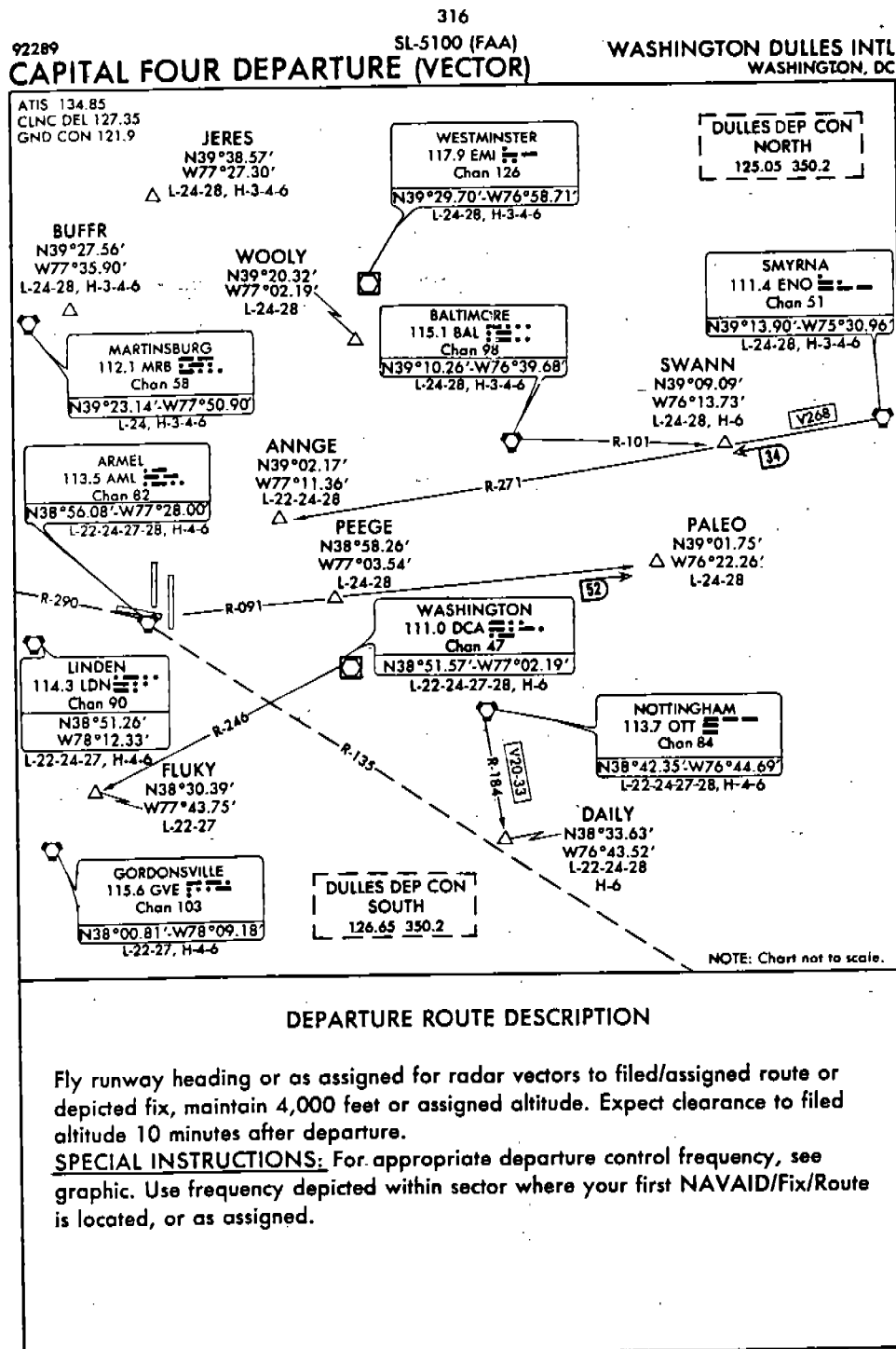
VOR/DME or TACAN RWY 12WASHINGTON DULLES INTL (IAD)
AL-5100 (FAA) WASHINGTON, DC**VOR/DME or TACAN RWY 12**

38°57'N - 77°27'W

WASHINGTON, DC
WASHINGTON DULLES INTL (IAD)

313

Figure 7-4 PUBLISHED INSTRUMENT APPROACH PROCEDURES



CAPITAL FOUR DEPARTURE (VECTOR)

WASHINGTON, DC
WASHINGTON DULLES INTL

Figure 7-5 PUBLISHED STANDARD INSTRUMENT DEPARTURE (SID)

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8.0 LESSONS LEARNED

8.1 Testing

Though valuable information was gathered during this test series, an emphasis must be placed on formal test planning to ensure a more efficient study and documentation of events.

8.1.1 Test Protocols

A formalized Test Protocol needs to be developed for all testing. It is quite apparent that the test team worked well together; however, greater detail needs to go into pre-test documentation and planning. This will ensure that all participants have the knowledge of the full details for the test to be conducted from all phases. In addition this document could be a vital logistics, support, and test team members roles and responsibility document in the event that a key player is unable to perform his or her assigned task.

A recommended, though never complete, "TABLE OF CONTENTS" of a specific test protocol could include the following:

A) Introduction

- 1) Purpose
- 2) Organization of Test Plan
- 3) Project Background
- 4) Test Purpose and Objectives

B) Test Description and Parameters

- 1) General Test Description

C) Pre-Test Preparation

- 1) Existing Data
- 2) Test-Site Support
 - a) Equipment Requirements
 - b) Aircraft Preparation
 - c) Explosives Support
 - d) Emergency Services
- 3) Photographic Requirements
- 4) Test Equipment Requirements
- 5) Security Requirements
- 6) Pre-Test Briefing
- 7) Equipment Validation
- 8) Aircraft Drawings

D) Test Procedures

- 1) Test Conduct and Procedures
 - a) Final Conditions Survey
 - b) Equipment Test and Check
 - c) Placement of Emergency Services
 - d) Test Site Clearing
 - e) Weapon Arming
 - f) Weapon Firing
 - g) Mis-Fire Contingency
 - h) Shutdown Procedures

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- i) Aircraft and Site Examination
- j) Data Collection (Before, During, and After)
- k) Site Clean-Up

E) Safety

- 1) Safety Practices
- 2) Emergency Services
- 3) Emergency Contingencies

F) Documentation

- 1) Content
- 2) Format
- 3) Classification
- 4) Distribution

APPENDIX

- A) Test Check List
- B) Data Collection Sheet
- C) Point of Contacts

8.1.2 Safety

An emergency fire and medical team should be on the test site during weapons detonation and an adequate first aid kit on the site at all times.

While on the test site ensure that there is at least a portable water-based fire fighting unit readily available.

8.1.3 Documentation

Physical data must be collected before, during, and after any test. The development of a data collection sheet will assist greatly in this task (Appendix C).

It must be emphasized that the purpose of conducting any test is to gain knowledge and record data for dissemination. Still and motion pictures, though extremely helpful, are not adequate without written documentation for substantiation. It will never pay to conduct any test unless a documentation plan is adequately incorporated into the test protocols.

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9.0 RECOMMENDATIONS

- 1) Conduct a literature search relating to any items regarding MANPADS theory, capabilities, performance, and counter-measures. This will include enquiring data bases from government and industry.
- 2) Team up with various intelligence sources to determine a MANPADS threat to world-wide commercial air transportation.
- 3) After conducting recommendations 1) and 2) determine if there are any technical or intelligence gaps and pursue them.
- 4) Publish and disseminate, to the appropriate organizations, all findings relating to recommendations 1), 2), and 3).

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APPENDIX A
MANPADS CHARACTERISTICS AND PERFORMANCE

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MANPAD SYSTEM PERFORMANCE REFERENCE						
MODEL	Max Speed	Max Range	Min Range	Max Altitude	Min Altitude	Guidance
MSA-3.1	1300 m/s	6000 m	150 m			ACLOS
HN-5		4400 m	800 m	2300 m	50 m	IR Seeker
Sakr Eye	280 m/s	4400 m		2400 m	50 m	IR Seeker
Matra Mistral	Mach 2.6	4000-6000 m	300 m	4500 m	15 m	IR Seeker
Keiko		3000-5000 m				CCD
Anza		500-5000 m				IR Seeker
SA-7b (ROM)	Mach 1.5	2800-4200 m		4500 m	15 m	IR Seeker
RBS-70 Mk-1	Supersonic	5000-6000m	200 m	3000 m	Ground Level	Laser Beam Riding
RBS-70 Mk-2	Supersonic	6000-7000 m	200 m	4000 m	Ground Level	Laser Beam Riding
SA-16	Mach 2.0	App 7000 m	600 m	6900 m	10 m	IR Seeker
SA-14	Mach 1.5	5300 m	600 m	5500 m	10 m	IR Seeker
SA-7a (SOV)	Mach 1.5	5000 m	800 m	4000 m	50 m	IR Seeker
SA-7b (SOV)	Mach 1.5	5000 m	800 m	4500 m	30 m	IR Seeker
Starstreak	1400 m/s	7000 m	300 m			Laser Beam Riding
Starburst	Mach 1 Plus	4000 m				Laser Beam Riding
Javeline	Mach 1	4500-5500 m	300 m	3000 m	10 m	SACLOS
Blowpipe	Mach 1	3500 m	700 m	2500 m	10 m	IR /CLOS
Stinger-92A	Mach 2.2	> 4000 m	200 m	3500 m	Ground Level	IR Seeker
Stinger-92B/C	Mach 2.2	> 4500 m	200 m	3800 m	Ground Level	IR/UV Seeker
Redeye	Mach 1.6	5500 m	500 m	2700 m	Ground Level	IR Seeker
Strela-2M/A	Mach 1.5	2800-4200 m		2300 m	15 m	IR Seeker
NOTES						
A) ACLOS: Automatic-To-Line-Of-Sight						
B) CCD: Charge Coupled Device						
C) SACLOS: Semi-Automatic-To-Line-Of-Sight						
D) CLOS: Command-Line-Of-Sight						
E) (ROM): Romanian Variant						
F) (SOV): Soviet/Russian Variant						
G) 1 meter (m) = 3.281 feet						

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BRAZIL

Orbita MSA-3.1 Low Altitude Surface-To-Air High Velocity Missile System

Description: The MSA 3.1 is a portable missile system guided by an Automatic-Command-To-Line-Of-Sight (ACLOS) system using a digital coded laser link to the missile with a stabilized sight and auto-tracker that follows a flare at the base of the weapon. Upon firing, the missile is initially boosted out of its launcher-container to a point clear of the gunner where its solid propellant rocket motor can ignite to increase its speed to a maximum of 1300 meters per second (m/s).

The nose of the missile contains the gyro package, thermal battery, motor ignition delay unit, command link detector, receiver and decoder units, guidance command processing unit, and the single kinetic energy warhead with a tungsten angular cutter.

Flight control is achieved by lateral thrusters and control systems utilizing digital electronic circuits. The single shot kill probability is assessed at 0.75.

SPECIFICATIONS

TYPE: two-stage, high velocity, low altitude

LENGTH

missile plus launch tube: 1.580 m

missile: 1.500 m

DIAMETER: .060 m (missile)

WEIGHT

complete system: 23.0 kg

missile at launch: 12.4 kg

GUIDANCE: Automatic-Command-To-Line-Of-Sight

MAX SPEED: 1300 m/s

MAX ENGAGEMENT RANGE: 6000 m

MIN RANGE: 150 m

DEPLOYMENT

Missile still in development phase.

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CHINA, PEOPLE'S REPUBLIC

CPMIEC Low Altitude Surface-To-Air Missile System

Description: CPMIEC is developing a semi-active MANPAD system for the Chinese Armed Forces. The system will be designed to be operated by two and will have an integral illuminator as part of the launcher assembly.

Propulsion is provided by a rocket ramjet which will give the missile a maximum range capability of approximately 8000 m and a maximum engagement altitude of approximately 5000 m.

CPMIEC HN-5 Series Manportable Anti-Aircraft Missile System

Description: The HN-5 consists of an expendable launch tube which serves as an aiming device and launcher, as well as a carrying case, a grip stock firing unit (mounted under the forward part of the launcher which provides launch information and ensures correct firing of the missile), and a thermal battery mounted on the forward part of the grip-stock to provide power.

The 13 kilogram (kg) missile is composed of four sections: the IR seeker section which is fitted with both the cooling and background noise rejection device; the control actuator which contains the gas generator; the warhead and fuze; and the rocket motor with rear fin attachment. The IR seeker is designed to detect the thermal radiation emitted from the target and converts this information into missile steering commands.

SPECIFICATIONS

TYPE: single stage, low altitude

WEIGHT: 16 kg (including launcher)

MAX ENGAGEMENT RANGE: 4400 m (slant)

MIN ENGAGEMENT RANGE: 800 m (slant)

MAX ALTITUDE: 2300 M

MIN ALTITUDE: 50 M

DEPLOYMENT

China, People's Republic, North Korea. Variant supplied to Afghanistan (Mojahedin), Iran, Iraq, Thailand, Pakistan

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Figure A-1 CPMIEC HN-5A

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EGYPT

Sakr Eye Low Altitude Surface-To-Air Missile System

Description: The Sakr Eye consists of four components; The launch tube, battery, missile, and grip-stock. The missile is transported and launched from an expendable tube which is made of glass fiber and is fitted with two aiming points positioned on the left forward side, an acquisition indicator, and a thermal battery mounted under the front which has sufficient power for 40 seconds.

The missile is a fire-and-forget system and consists of an IR homing head, guidance and control, warhead, and propulsion section. The grip-stock combines the firing mechanism and the logic circuits. When attached to the launch tube it carries out the firing sequence and authorizes the ejection of the missile in either a manual or automatic mode.

In the absence of an integrated IFF system a typical target engagement is as follows: the gunner acquires the target and aligns the weapon using the open sight and selects either manual or automatic mode; audio and visual cues indicate to the gunner that the target is within the weapons range. The trigger is then squeezed according to the selected mode and the missile is ejected from the launch tube by a small rocket motor. After a short delay the sustainer motor is ignited to propel the missile to its target. If the target is not encountered within 16 seconds the missile will self-destruct. The High Explosive (HE) warhead is detonated by a contact or grazing fuze.

The Sakr Eye ammunition container has two missiles fitted with thermal batteries, plus two spare batteries, while the grip-stock container has one grip-stock.

The system takes approximately 10 seconds to be prepared for action and can engage an aircraft traveling at a maximum speed of 280 m/s in pursuit or 150 m/s in a head-on attack.

SPECIFICATIONS

TYPE: two stage, low altitude

LENGTH: 1.4 m (missile)

DIAMETER: 0.072 m (missile)

WEIGHT

missile: 9.9 kg

launcher: 5.1 kg

PROPULSION: solid fuel booster and solid fuel sustainer rocket

WARHEAD: HE smooth fragmentation with contact and grazing fuze

MAX SPEED: 280 m/s

MAX ENGAGEMENT RANGE: 4400 m

MAX ENGAGEMENT ALTITUDE: 2400 m

MIN ENGAGEMENT ALTITUDE: 50 m (150 m for helicopters)

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DEPLOYMENT

Egypt, Afghanistan (Mojahedin)



Figure A-2 Sakr Eye

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FRANCE

Matra Mistral SATCP Low Altitude Surface-To-Air Missile System

Description: The Mistral system consists of the missile in its container-launcher tube, a vertical tripod stand, a pre-launch electronics box, a day-time only sighting system, and the battery/coolant system. A Forward-Looking-Infra-Red (FLIR) thermal sight is used for night time firing. The basic assembly can be broken down into two 20 kg loads.

The missile is a two stage cylindrical type missile with a booster motor to eject it from the launch tube and a sustainer motor to propel it on to the target. Flight control is accomplished through the use of one pair of movable canards located forward of the missile. The 2.95 kg HE-fragmentation warhead uses one kg of explosive and layers of tungsten balls to increase penetration of the target. The fuzing system is either contact or proximity. The proximity fuze is an active laser-type. This is an advantage over other types of proximity fuzes which are prone to detonate prematurely due to false target returns.

The cooled passive IR seeker has a multiple sensor which digitally processes incoming signals in the 3-5 μm IR region of the spectrum. This allows acquisition of a non-after burning aircraft to be tracked at ranges of 6000 meters and light helicopter with reduced IR signatures at 4000 meters. The seeker head can move through a $\pm 38^\circ$ with a narrow field-of-view after lock-on.

An IR transparent magnesium fluoride pyramidal-shaped seeker cover is used so as to reduce the drag normally found at the upper end of the speed range with more conventional cover shapes. This increases the missiles maneuverability during the terminal phase of the flight allowing the Mistral to track on evasive targets.

To prepare the Mistral for firing the missile, in the container, is fitted together with the battery/coolant unit, the sighting device, and the pre-launch electronics box. The box carries out the following functions during an engagement: it determines the field and sensitivity of the seeker using the target data derived from the seeker head looking at the aiming point; from this data it either rejects it as a false target or confirms it as a valid target by calculating target information for launch. The battery/coolant unit supplies the electrical power required prior to launch and supplies the coolant for the seeker head lock-on. Once initiated the unit operates for 45 seconds after which it has to be replaced.

Once a gunner designates and tracks a target he activates the system where all aiming data is continuously displayed via a clear collimator system which allows the gunner to follow the pre-launch sequence and assesses the target's track. He then releases the safety lever and activates the seeker activation lever energizing the battery/coolant system. After two seconds the system is stabilized for the seeker to lock-on and feeds target data into the missile system. When the target is validated and within range the gunner depresses the firing trigger. This causes the missile's double-based extruded motor to ignite which propels the missile safely from the launch tube at 40 m/s. At approximately 15 meters the booster motor falls off and the sustainer motor fires to accelerate the missile to its maximum speed.

The weapon tracks on the target's exhaust plume by the onboard passive IR homing system where data is continuously fed to the missile's flight control. A final forward correction or lead is calculated where a proximity fuze detonates the warhead.

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SPECIFICATION

TYPE: two stage, low altitude

LENGTH

missile: 1.81 m

container-launch tube: 1.85 m

DIAMETER: 0.0925 m (missile)

WING SPAN: 0.19 m

WEIGHT

missile: 18.4 kg

container-launcher tube: 21.4 kg

PROPULSION: solid fuel ejector rocket motor with solid fuel sustainer
rocket motor

GUIDANCE: IR passive homing

WARHEAD: 2.95 kg HE fragmentation with contact and active laser
proximity fuze

MAX SPEED: 2.6 Mach

MAX ENGAGEMENT RANGE: 4000-6000 m depending on target type

MIN ENGAGEMENT RANGE: 300 m

MAX ENGAGEMENT ALTITUDE: 4500 m

MIN ENGAGEMENT ALTITUDE: 15 m

DEPLOYMENT

France, Belgium, Finland, Italy, Selenia, Spain, Norway, Abu Dhabi,
Cyprus, Saudi Arabia, Qatar, Singapore, Malaysia, Gabon, Kenya, Chile



Figure A-3 Matra Mistral

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JAPAN

Toshiba Keiko Low Altitude Surface-To-Air Missile System

Description: The missile is believed to a standard technology booster and sustainer rocket. The technological advance is located in the homing system which is a dual-mode imaging type which uses both IR and visual light region guidance wavelengths. The gunner locks the seeker head onto the target where upon the high resolution Charge Coupled Device (CCD) memorizes the target's appearance and causes the weapon to follow an all-aspect attack flight profile which is extremely resistant to any defensive countermeasures that may be employed.

DEPLOYMENT

Currently under development.

PAKISTAN

Anza Low Altitude Surface-To-Air Missile System

Description: The Anza (Lance) was developed under the auspices of the Pakistani Military Research Laboratories. Approximately 70% of the missile is of indigenous design with the remainder, most likely the IR seeker head, of Chinese origin.

The estimated range of the Anza is 500 - 5000 m.

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ROMANIA

SA-7b (Strela-2M/9K32M) Low Altitude Surface-To-Air Missile System

Description: The Soviet Strela-2M (Soviet industrial index number 9K32M) MANPAD missile system is being developed through a license by the Romanian armaments industry and specifically made to destroy targets that have been visually acquired such as helicopters and aircraft.

Against jet aircraft moving at speeds of 260 m/s the best engagement aspect is a pursuit flight profile, while for propeller driven aircraft and helicopters at speeds up to 160 m/s a pursuit head-on engagement is possible.

The Strela-2M missile system consists of the following components (shown with Soviet industrial code index):

- a) Disposable Thermal Battery Power Supply Unit (9B17)
- b) Disposable Launch Tube (9P54M)
- c) Grip-Stock Launching Mechanism (9P58)
- d) Missile (9M32M)

The missile is made up of the following sections:

- a) Nose Section: A single channel passive IR transparent seeker (designated TGS or teplovaya golvka samonevedeniya) and auto pilot that receives the target signal from the TGS and creates the guidance commands that are sent to the missiles control section.
- b) Control Section: With the missile control vanes; the angular speed sensor (designated DUS for datchik uglovykh skorostej) which senses the angular speed of the missile oscillations, and translates them into signals used to stabilize the missile on its desired flight trajectory; a solid-propellant gas generator, and an onboard power supply, which powers the control vanes and comprises a turbine driven by diversion of exhaust gas from the burning propellant charge.
- c) Warhead Section: A 1.15 kg HE chemical energy (0.37 kg HE charge) fragmentation warhead and detonating system. The latter comprises a remote control arming device, contact and grazing fuze circuits, and a self-destruct mechanism.
- d) Propulsion Section: A launch booster that provides the missile with its initial velocity of 28 m/s. Once clear of the gunner (five to six meters), and with all four rear fins deployed, the sustainer motor fires and propels the missile up to its maximum speed. Between 80 and 250 meters the second stage motor fires. A total weight of 4.2 kg of solid propellant fuel is carried.

The glass fiber tube is used to transport, aim, and launch the missile. The grip-stock is attached to it and acts as a launching mechanism. Fitted to the grip-stock is the thermal battery power unit, which supplies both 22 V and 40 V DC to the grip-stock electronics, missile electronics, and missile seeker head.

Following a 1 to 1.3 second activation period, the battery will supply power for 40 seconds until it has to be replaced.

The complete missile system is capable of operating at a relative humidity level of 98% between -40 and +50°C.

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SPECIFICATIONS

TYPE: two stage, low altitude

LENGTH

missile (fins folded): 1.440 m

container-launch tube: 1.500 m

DIAMETER: 0.072 m (missile)

WEIGHT

missile: 9.85 kg

launcher assembly: 16.00 kg

PROPULSION: solid fuel booster and solid fuel sustainer rocket motor

GUIDANCE: single-channel passive IR homing

WARHEAD: 1.15 kg HE-fragmentation with contact and grazing fuze

MAX SPEED: Mach 1.5

MAX ENGAGEMENT RANGE: 4200 m (receding), 2800 m (approaching)

MAX ENGAGEMENT ALTITUDE: 4500 m

MIN ENGAGEMENT ALTITUDE: 15 m

MISSILE SELF DESTRUCT TIME: 14-17 s after launch

DEPLOYMENT

Romania

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SWEDEN

Bofors RBS 70 Series Low Altitude Surface-To-Air Missile System

Description: The RBS 70 missile series (there is a Mk 1 and Mk 2) has a two-stage solid propellant rocket motor. It is never removed from its container-launcher tube when in the field but once fired the tube is discarded. Both impact and laser proximity fuzes are employed in the missile that is fitted to a HE-fragmentation warhead that is surrounded by numerous tungsten pellets.

The proximity fuze is set for short-range activation so as to avoid premature detonation during operations close to reflecting surfaces such as ice, snow, or water. For very low altitude targets, such as helicopters, it can be disabled before flight by means of a switch on the gunners left-hand aiming grip, so that the weapon actually needs to hit the target with its contact-fuze in order to score a kill. A shape charge is incorporated in the warhead that is capable of penetrating all aerial armored targets.

In addition to the essentially smokeless sustainer rocket motor, the missile body also houses a receiver unit which senses deviation from the line-of-sight and a small computer which converts these deviations signals into guidance pulses that command the missile to automatically follow the center of the laser beam.

For an engagement the tubular stand assembly is removed from its carrying harness and the three legs unfolded. The operators seat is then unfolded from the vertical central tube and the gyro stabilized sight, power supply, IFF unit, and launcher-container missile tube are attached.

On engaging a target the gunner acquires a visual sighting where he slews the system onto a rough bearing of the target and releases the weapon's safety catch, activating the electronics for the missile launch system, and commences aiming with a reticule sight. The IFF equipment, if fitted is automatically activated at the same moment as it transmits the interrogation signal. If a friendly signal is received the firing circuit is overridden and visual signal lamps in the aiming sight indicates to the gunner that this happened.

The range is gauged by means of a graticule with a head-on fighter-sized target which is indicated as being in range when it appears to be bigger than half the central gap in the effective engagement. Once the gunner is satisfied that the conditions are correct he launches the missile, maintaining his aim till missile impact by guiding the gyro stabilized optical sight with a thumb joystick.

SPECIFICATIONS

TYPE: two stage, low altitude

LENGTH

missile: 1.320 m
container-launch tube: 1.745 m

DIAMETER

missile: 0.106 m
container-launch tube: 0.152 m

WING SPAN: 0.32 m

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WEIGHT

Mk 1 (missile): 16.0 kg
Mk 2 (missile): 16.5 kg
launcher-container: 26.6 kg
stand: 25 kg
sight, pad, and carrying case: 35 kg

PROPULSION: solid fuel booster and solid fuel sustainer rocket motor

GUIDANCE: modulated laser-beam riding

WARHEAD

Mk 1: 1 kg HE-fragmentation with contact and active laser proximity
Mk 2: larger with fragmentation shaped-charge and similar fuzing

MAX SPEED: supersonic

MAX ENGAGEMENT RANGE

Mk 1: 5000 m (high speed targets), 6000 m (low speed targets)
Mk 2: 6000 m (high speed targets), 7000 m (low speed targets)

MIN ENGAGEMENT RANGE: 200 m

MAX ENGAGEMENT ALTITUDE

Mk 1: 3000 m
Mk 2: 4000 m

MIN ENGAGEMENT ALTITUDE: ground level

DEPLOYMENT

Argentina, Australia, Bahrain, Iran, Ireland, Indonesia, Norway,
Pakistan, Singapore, Sweden, Taiwan, Tunisia, United Arab Emirates,
Venezuela

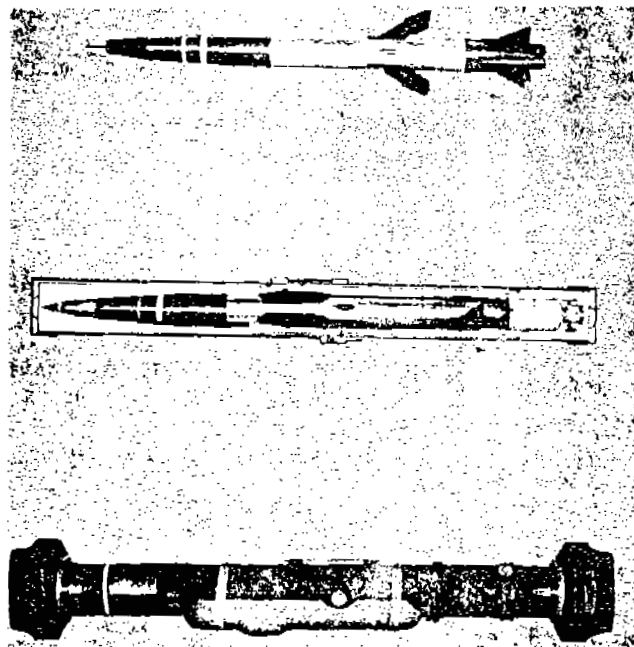


Figure A-4 Bofors RBS 70

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TAIWAN

CSIST Low Altitude Surface-To-Air Missile System

Description: The Chung Shang (or Sun-Yat-sen) Institute of Science and Technology (CSIST) is developing a man portable laser guided low altitude SAM system.

It is expected to be physically similar to the Swedish RBS 70 system

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UNION OF SOVIET SOCIALIST REPUBLICS/RUSSIA

SA-18 Low Altitude Surface-To-Air Missile System

Description: Sources have indicated the fielding of an improved Soviet/Russian MANPAD system which has been assigned the US designation SA-18. Apart from being reported as being in service in field test quantities during 1990 no further information is available.

SA-16 "Gimlet" Low Altitude Surface-To-Air Missile System

Description: A PZRK (perenosniy zenitniy kompleks: portable air defense system) known to the Soviets/Russians as Igla-1 (Russian for needle) is a system comprised of a missile in a 9M39 launching tube with grip-stock launching mechanism and portable battery power unit. It is essentially a new system with a changed shape around the shoulder rest (the battery/coolant reserve is canted downward at an angle about 10° relative to the launcher tube) is a frangible nose cap and a modified firing mechanism. The nose is a conical pyramidal shape similar to that of the French Mistral. The system was used by Iraq during the Gulf War and scored most of the MANPAD system kills against the Coalition Force aircraft (including four McDonnell Douglas AV-8B Harrier II).

Guidance is by proportional navigation using a cooled seeker unit. Maximum target bearing angle for a launch is +/- 40°.

In the Finnish Army the system is called the 86 Igla and is linked to external target acquisition and control systems. These modifications include the use of a locally made IR target finder with automatic search. A fire command unit allows firing instructions to be data-linked from a command vehicle to the gunner.

SPECIFICATIONS

TYPE: two stage, low altitude

LENGTH: 1.55 m

DIAMETER: 0.80 m

WEIGHT

missile: 10.8 kg

launcher assembly: 4.2 kg

PROPULSION: two-stage solid propellant booster and sustainer

GUIDANCE: cooled IR homing

WARHEAD: 2 kg HE-fragmentation with contact and grazing fuze

AVERAGE SPEED: Mach 2.0

MAX ENGAGEMENT RANGE: approximately 7000 m

MIN ENGAGEMENT RANGE: 600 m

MAX ENGAGEMENT ALTITUDE: 6900 m

MIN ENGAGEMENT ALTITUDE: 10 m

DEPLOYMENT

Angola, Finland, Iraq, Nicaragua, Soviet Union

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Figure A-5 SA-16 "Gimlet"

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SA-14 "Gremlin" Low Altitude Surface-To-Air Missile System

Description: Compared to the SA-7 series the SA-14 has an improved rocket motor, a more powerful warhead, and a cryogenically cooled passive IR homing seeker with proportional guidance so it can track both approaching and receding aircraft and other targets maneuvering at up to 8 g. It is also believed to incorporate IR signal processing to defeat IR countermeasures such as flares and modulated IR "hot brick" type decoys.

The missile is similar to the SA-7 but heavier. The grip-stock assembly has a ball-shaped battery at the front in contrast to the rear-mounted can-type battery of the SA-7. The weapon can also be fitted with a passive radio-frequency direction finder antenna system.

SPECIFICATIONS

TYPE: two stage, low altitude

LENGTH: 1.4 m

DIAMETER: 0.075 m

WEIGHT

missile: 9.9 kg

launcher assembly: 6.1 kg

PROPULSION: solid fuel booster and solid fuel sustainer rocket motor

GUIDANCE: cooled IR homing

WARHEAD: 2 kg HE-fragmentation with contact and grazing fuze

MAX SPEED: Mach 1.5

MAX ENGAGEMENT RANGE: 5300 m

MIN ENGAGEMENT RANGE: 600 m

MAX ENGAGEMENT ALTITUDE: 5500 m

MIN ENGAGEMENT ALTITUDE: 10 m

DEPLOYMENT

Angola, Cuba, Czechoslovakia, El Salvador (FMLN guerrilla group), Finland, Hungary, India, Iraq, Jordan, Nicaragua, Poland, Soviet Union, Syria, UAE (Abu Dhabi Royal Guard)

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Figure A-6 SA-14 "Gremlin"

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SA-7 "Grail" Low Altitude Surface-To-Air Missile System

Description: The PZRK (perenosniy zenitniy rakentniy kompleks: portable air defense system) is referred to by the Soviets/Russians as the Strela-2 (Russian for arrow). The system consists of a missile in its green (for operational round) launch-container (Soviet factory index 9P54 for the Strela-2 and 9P54M for the Strela-2M), a re-loadable grip-stock (Soviet factory index 9P53 for the Strela 2 with a 24 pin connector and 9P58 for the Strela-2M with a 28 pin connector), and a can like thermal battery.

To operate the system the gunner visually identifies and acquires the target. He then loads a missile in its disposable glass fiber container onto the grip-stock and pointing the launcher at the target he pulls the trigger back to its first stop to start the short-life battery and energizes the seeker head's sealed tracker unit. This contains a reflective optical system that is sensitive to heat and also acts as a space-stabilized gyroscope to aid the missile in flight.

It takes between four and six seconds to do this and once the seeker is energized and uncovered a red light on the launcher's optical sight is lit. As soon as the IR detector cells in the seeker detects the reflection of heat energy from the optical system a green light is activated on the sight and an audible warning is sounded by a small alarm under the rear of the grip stock near the gunner's ear.

The gunner then depresses the trigger fully and the missile is expelled by the first stage solid propellant booster motor to reach a speed of 28 m/s. This burns out in 0.05 seconds, before the tail of the missile departs the launch tube to protect the gunner from being burned. The booster then falls away at a safe distance from the launch position and the four spring loaded stabilizer tail-fins and the two canard control fins deploy as the missile coasts along.

Once this operation is complete the solid propellant second stage sustainer rocket motor ignites at approximately five to six meters from the gunner and 1.25 seconds into flight to accelerate the missile, within 1.8 seconds, to its maximum speed.

The seeker head continuously determines the angle of the target's heat that is reflected and the on-board guidance system uses this data to resolve the difference between the direction that the head is pointing and the weapon's trajectory by moving the two variable-incidence control fins. Through out its fuel efficient lag-pursuit flight the missile spins in a counter-clockwise direction for stability.

The SA-7a (Strela-2) has a maximum speed of approximately Mach 1.5 and is effectively capable of engaging a target at a range of 5000 meters and at altitudes up to 4000 meters.

The SA-7b (Strela-2M) has a maximum speed of approximately Mach 1.5 and is effectively capable of engaging a target at a range of 5000 meters and at altitudes up to 4500 meters.

In both versions the missile contains 0.37 kg of HE and is armed after 45 meters of flight. It automatically self-destructs after 14 to 17 seconds of flight, which in this case the missile will be approximately 6000 meters down-range.

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SPECIFICATIONS

TYPE: two stage, low altitude

LENGTH

missile: 1.44 m (fins folded)

launcher: 1.50 m

DIAMETER

missile: 0.072 m

launcher: 0.100 m

WEIGHT

missile: 9.20 kg (Strela-2), 9.85 kg (Strela-2M)

launcher assembly: 4.17 kg (Strela-2), 4.95 kg (Strela-2M)

PROPULSION: solid fuel booster and solid fuel sustainer rocket motor

GUIDANCE: IR homing

WARHEAD: 1.15 kg HE-smooth fragmentation with contact and grazing fuze

MAX SPEED: Mach 1.5 (Strela-2), Mach 1.5 (Strela-2M)

MAX ENGAGEMENT RANGE: 5000 m (Strela-2), 5000 m (Strela-2M)

MIN ENGAGEMENT RANGE: 800 m

MAX ENGAGEMENT ALTITUDE: 4000 m (Strela-2), 4500 m (Strela-2M)

MIN ENGAGEMENT ALTITUDE: 50 m (Strela-2), 30 m (Strela-2M)

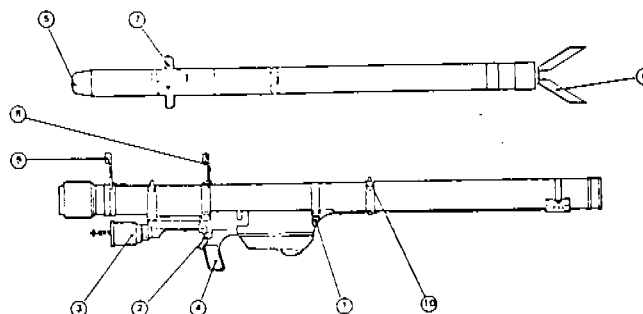
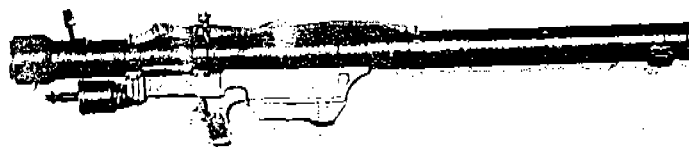
DEPLOYMENT

Afghanistan, Algeria, Angola, Argentina, Benin, Botswana, Bulgaria, Burkina Faso, Cambodia, Cape Verde Islands, Chad, People's Republic of China, Croatian militia, Cuba, Cyprus, Czechoslovakia, Egypt, Ethiopia, Finland, Ghana, Guinea, Guinea-Bissau, Guyana, Hungary, India, Iraq, Jordan, North Korea, Kuwait, Laos, Libya, Mali, Mauritania, Mongolia, Morocco, Mozambique, Nicaragua, Nigeria, Peru, Poland, Romania, Serbian militia, Seychelles, Sierra Leone, South Africa, Somalia, Soviet Union, Sudan, Syria, Tanzania, Uganda, Yemen, Yugoslavia, Zambia, Zimbabwe

DEPLOYMENT (GUERRILLA/TERRORIST)

Provisional IRA, Uniao Nacional para a Independencia Total de Angola (UNITA), Polisario Front, Sudanese Peoples Liberation Army (SPLA), Eritrean Liberation Front (ELF), Mozambiques National Resistance (MNR), Northern Armed Forces (FAN), Abu Nidal Group, Palestina Liberation Army (PLA), Palestinian Liberation Organization (PLO), Popular Front for the Liberation of Palestine-Liberation Command (PFLP-GC), Sa'iq, Al-Fatah, Christian Militia, Druze Militia, South Lebanon Army, Hezbollah, Amal Militia, Farabundo Marti National Liberation Front (FMLN), Liberation Tigers of Sri Lanka, Khmer Rouge, Moro National Liberation Front (MNLF), New People's Army (NPA), Khmer People's National Liberation Front (KPNLF)

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- | | |
|------------------------|---------------------------|
| 1 - LOCKING PIN | 8 - STABILIZING TAIL FINS |
| 2 - TRIGGER | 7 - STABILIZING FINS |
| 3 - THERMAL BATTERY | 6 - REAR SIGHT |
| 4 - GRIPSTOCK ASSEMBLY | 5 - FORE SIGHT |
| 5 - IR SEEKER HEAD | 10 - SLING PICKUPS |

Figure A-7 SA-7 "Grail"

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UNITED KINGDOM

Shorts Starstreak Close Air Defense Weapon System

Description: The missile itself consist of a two stage solid propellant rocket motor assembly with a payload separation system mounted on the front end of the second stage motor. This supports three winged darts which each have guidance and control circuitry, a high penetration explosive warhead, and delay action fuzing.

The aiming unit contains all the systems required for the engagement cycle and comprises two separate detachable assemblies:

- a) A light alloy casting hermetically sealed optical head with an optics stabilization system, aiming mark injector unit, and aimer monocular sight.
- b) A hermetically sealed control unit in a lightweight molded case which contains the power supply unit (with one lithium oxide battery pack) and the electronics units required for processing and control. An attached control handle contains the joystick controller, trigger assembly, system switch, wind offset switch, and super-elevation button.

In combat the gunner acquires the target in his monocular sight and selects "system-on" which energizes the aiming unit battery supply. A space stabilized aiming mark is injected into the center of the field-of-view of the aimer who then tracks the chosen target by moving the launcher assembly as to maintain the target in coincidence with the aiming mark. This permits lead angles in both azimuth and elevation to be generated and ensures the missile is brought into the target at the end of its boost phase.

After his pre-launch tracking phase is complete, the gunner presses the firing trigger which causes a pulse of power to be transmitted from the aiming system power supply to the missile booster unit where it causes the first stage rocket motor to ignite. The Starstreak is ejected from its launch tube by this motor which completely burns out within the length of the container in order to safeguard the gunner. The booster accelerates the missile to a high exit velocity while its canted exhaust nozzles impart sufficient roll on the weapon to create a centrifugal force that unfolds a set of flight stabilizing fins. The first stage motor then separates from the main missile body and falls away as the Starstreak emerges from its canister.

At a safe distance from the gunner, and less than a second into the flight, the main second stage rocket motor ignites to accelerate the missile to an end-of-boost velocity to approximately mach three to four. As the motor burns out, the attenuation of the thrust triggers the automatic payload separation of the three darts which, upon clearing the missile body, are independently guided in a fixed triangular formation by their individual onboard guidance systems using the launcher's laser designator beam and grid matrix.

The darts ride the laser beam projected by the aiming unit which incorporates two laser diodes. One of which is scanned horizontally and the other vertically to produce a two dimensional matrix. Each dart then uses its onboard guidance package to control a set of steerable fins so as to hold its flight formation within this matrix. Separation of the darts also arms the warheads.

The darts, about 0.45 meters long, 0.02 meters in diameter, and made of a dense alloy, rely primarily on their kinetic energy for target penetration, with the impact forces generated activating the delay action fuze mechanism so that the explosive component (more than 50 per

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cent of the darts total weight) detonates within the confines of the target for maximum effect.

All the gunner has to do is track and maintain his sight picture by use of the joystick. Maximum effective range is 7000 meters which is the maximum distance where the darts can retain sufficient maneuverability and energy to catch a nine g maneuvering target.

A Starstreak does not rely on a heat source for guidance, it can engage target from all aspects. A single shot probability of kill is 0.96.

SPECIFICATIONS

TYPE: two stage high velocity low altitude

LENGTH: 1.397 m

DIAMETER

missile: 0.127 m

missile in canister: 0.274 m

PROPULSION: two stage booster/sustainer solid propellant rocket motor

GUIDANCE: beam riding laser

WARHEAD: triple kinetic/high explosive sub-munitions

MAX SPEED: 1400 m/s

MAX ENGAGEMENT RANGE: 7000 m

MIN ENGAGEMENT RANGE: 300 m

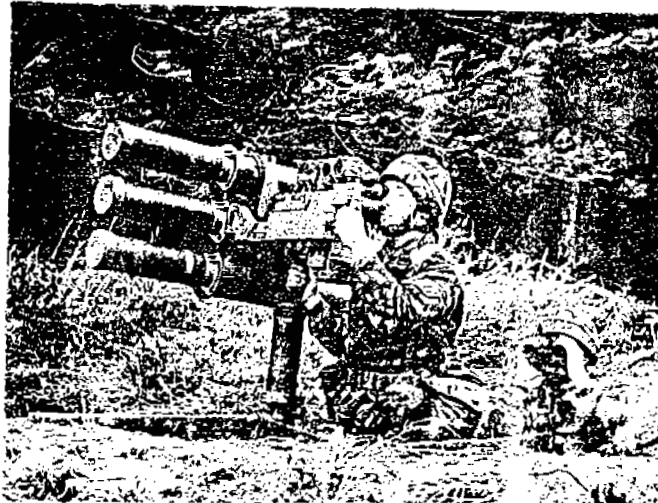


Figure A-8 Shorts Starstreak

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Shorts Starburst Low Altitude Surface-To-Air Missile System

Description: The Starburst consists of a two stage motor, pre-fragmented blast warhead and dual mode (impact/proximity) capacitance fuze. Twist and steer commands are sent to the forward-mounted steering control surfaces while ballistic stability is provided by the rear fins, which also houses the two interconnected laser transceiver guidance units. The latter acts as the relays between the aiming unit and the missile's forward-positioned electronics and controls section.

Each of the transceiver units incorporates a laser receiver, a signal processor, and a transmitter in a small cylindrical pod. The reason for two electrically interconnected pods being fitted are system redundancy and the prevention of any possible screening effects acting upon the guidance signals.

The transmitter is mounted in the nose of the pod and relays the command up-link data to the missile's forward-mounted electronics. The optical data signals are detected by small pop-up antennas connected to the control unit which, apart from software changes, is essentially unchanged from that of the Javelin.

The missile canister is a sealed lightweight environmental container which acts as a recoilless launcher-tube and is discarded after use. It houses an electrical interface connector to pass firing signals from the aiming unit to the missile. At launch the front cap of the canister is blown off by the gas pressure when the missile gyro is fired.

The reusable aiming unit consists of a guidance head and control unit. The former, which requires no alignment procedure, has an optical stabilization system, a guidance transmitter, an aiming mark injector, and a six power magnification monocular sight; all housed in an environmentally sealed light alloy casing.

The control unit consists of a lightweight molded case with an environmentally sealed compartment (containing the wind off-set switch and electronic processing assemblies for processing and control), an externally mounted battery box and an attached control handle assembly. The control handle contains the joystick, trigger, system on/off switch, fuze selection switch, and super-elevation button.

In combat when the gunner receives a target indication he acquires it in the monocular sight and selects "system on". He then tracks the target by moving the weapon system so that coincidence is maintained with the aiming mark. This action automatically generates the lead angles, in both azimuth and elevation. The gunner then actuates the trigger mechanism.

The missile is launched from the canister by the first stage motor and, at a safe distance from the gunner, is boosted to supersonic velocity by the second-stage rocket motor. The gunner continues to track the target by keeping the aiming mark superimposed over it by the thumb operated joystick. The guidance system lock-on is automatically maintained on the center of the aiming ring.

On reaching the target the missile's warhead is detonated either by impact or a proximity fuzing circuit. If after launch it is determined that the target is in fact a friendly aircraft, the gunner has the ability to self-destruct the weapon.

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SPECIFICATIONS

TYPE: two stage low altitude

LENGTH: 1.394 m

DIAMETER: 0.197 m

WEIGHT

aiming unit: 8.5 kg

missile in canister: 15.2 kg

PROPULSION: two stage propellant rocket

GUIDANCE: beam riding laser

WARHEAD: 2.74 kg HE fragmentation with contact and proximity fuze

MAX SPEED: Mach 1 plus

MAX ENGAGEMENT RANGE: 4000 m



Figure A-9 Shorts Starburst

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Shorts Javelin Low Altitude Surface-To-Air Missile System

Description: The Javelin MANPAD system consists of two components: the missile sealed within the launching-canister and arming unit, and the lightweight carrying cases for both.

The canister in which the missile is factory-sealed is a lightweight environmental container designed to act as a recoilless launcher. It houses the guidance aerial, the electrical connections, and the thermal battery to power the aiming unit after missile launch.

The front cap is blown off by gas pressure when the missile gyro is fired and the laminated rear closure is ejected at launch.

The missile is a 1.4 meter long slender tube with the fuzes in the tip and the warhead in the center. The guidance equipment is in the forward part of the body and the rocket motors are in the rear. There are four delta-shaped aerofoils in the nose for aerodynamic control and four at the rear for ballistic stability. A self-destruct unit is incorporated.

The nose section is free to rotate independently of the main body, to which it is attached by a low-friction bearing. Twist and steer commands to the control fins guide the missile with a high-response rate.

The aiming unit is a self contained firing and control pack with a pistol grip firing handle on the right side. It contains a stabilized sighting system which provides manual target tracking and automatic missile guidance through a solid-state TV camera.

Digital commands from the camera are fed to a microprocessor and the resultant guidance commands are transmitted to the missile by radio. The simple controls on the handle include the firing trigger, thumb controlled joystick, fuze mode, and super-elevation switches. Other controls include channel selector switches for the transmitter and an automatic cross-wind correction switch.

The automatic gather and guidance system comprises a miniature solid-state CCD, television camera and zoom lens, signal processing electronics, and a two axis sub-miniature gyro assembly. The complete electro-optical and gyro subsystem are contained within the operator lightweight aiming unit.

The Javelin is made ready for action by clipping the aiming unit onto the canister.

Information of an imminent attack can be received over the radio net or the team scanning the horizon visually. The gunner acquires the target in the monocular sight and switches the system on, selecting the frequency of the guidance transmitter, and the fuze mode (contact or proximity). This activates the tracking electronics and projects an illuminated stabilized aiming mark (a red circular reticula) into the field-of-view (FOV). The target is tracked briefly with the aiming mark to establish a lead angle, the safety catch is released, and the trigger pressed.

The firing trigger activates two thermal batteries, one of which supplies the power to the aiming unit while the other provides power to the missile.

The gyro of the missile is run up by the action of a cordite burning charge initiated by the battery. The gas overpressure blows off the canister sealing cover and the missile is boosted from the canister by the first stage motor which burns out in 0.2 seconds before the missile

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emerges from the tube. At a safe distance from the gunner, the sustainer motor activates and the weapon accelerates to its supersonic speed.

The Javelin's wing assembly comprises four wings mounted on a central tube and is housed at the forward end of the canister until the round is launched. The wingtips are folded in this stowed position to reduce the diameter of the canister. While the missile is being launched, the main body of the missile passes through the wing assembly which is arrested by a band of tape around the rear of the body. When the missile is clear of the launch canister, its wingtips are unfolded by a roll action that the booster motor applies to the rear body. A slight cant on the wing then rolls the missile continuously throughout flight in order to maintain aerodynamic stability.

The missile is not armed until it is safe distance from the gunner. If the missile has lost acquisition or losses guidance signals the weapon self-destructs.

SPECIFICATIONS

TYPE: two stage low altitude

LENGTH: 1.39 m

DIAMETER: 0.076 m

WING SPAN: 0.275 m

WEIGHT

aiming unit: 8.9 kg

missile: 12.7 kg

missile in canister: 15.2 kg

PROPULSION: two stage solid propellant rocket

GUIDANCE: semi-automatic command to line-of-sight (SACLOS)

WARHEAD: 2.74 kg HE fragmentation with contact and proximity fuze

HE CONTENT OF WARHEAD: 0.6 kg

FOV

monocular: 180 mils

magnification: x 6

TV FOV:

wide: 230 x 180 mils

narrow: 36 x 36 mils

MAX SPEED: Mach 1

MAX ENGAGEMENT RANGE: 5500 m (helicopters), 4500 m (jet aircraft)

MIN EFFECTIVE RANGE: 300 m

MAX EFFECTIVE ALTITUDE: 3000 m

MIN EFFECTIVE ALTITUDE: 10 m

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Figure A-10 Shorts Javeline

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Shorts Blowpipe Low Altitude Surface-To-Air Missile System

Description: The Blowpipe system consists of two main components; the missile sealed within its launching-canister and the arming unit, with lightweight carrying cases for both.

The Blowpipe missile itself is a slender tube 1.4 meters long with the warhead in the center section and the fuzes in the tip of the nose. The forward part of the body contains the guidance equipment and the rocket motors are to the rear.

The 0.2 second burning time of the booster stage is achieved by using the thin sections of high burn rate pressurized propellant. Roll is induced in the missile by suitably angling the small nozzles drilled through the rear end plate.

The second stage sustainer uses a conventional double-base propellant to minimize smoke emission and exhausts its gasses by ducting through the center of the first spent stage booster motor via a lined blast pipe.

There are four delta-shaped aerofoils in the nose for aerodynamic control and four at the tail to provide ballistic stability. The aerofoils are of supersonic double-wedge profile.

When a period of five seconds passes without guidance signals being received, a self-destruct mechanism activates. This is command activated by the gunner or automatically activated when the missile fails to remain on course.

An unusual feature of the Blowpipe is that the nose section of the missile is free to rotate independently of the main body, to which it is attached by a low-friction bearing. Twist and steer commands to the control fins guide the missile at a very fast response rate.

The container in which the missile is factory sealed in is a lightweight environmental canister designed to act as a recoilless launcher and houses the firing sequence unit, the thermal batteries, and electrical connections.

The aiming unit is a self-contained firing and control pack with a pistol grip at the right side and contains a radio transmitter, an auto-gathering device, a monocular sight, and an optional IFF interrogator system. The controls consists of a trigger, thumb-controlled joystick and switches for fuze option, auto-gather, and guidance command frequency change

The Blowpipe is made ready in less than five seconds by clipping the aiming unit onto the canister. The gunner then grasps the front of the canister with his left hand and clips the hand grip on the aiming unit with his right hand and supports the remainder of the launcher with his right shoulder.

He acquires the target in a five power monocular sight. He then switches on the system, selects the frequency of the guidance transmitter unit and the mode of the fuze (proximity or contact).

In addition to the monocular sight, the aiming unit is also fitted with a sensor which detects the position of the missile in relation to the line-of-sight. The missile is fitted with flares which provide outputs for both visual and automatic IR tracking. The error signals generated in the sensor are also sent to the missile via a radio transmitter in the aiming unit and an aerial in the canister.

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A receiver in the missile then passes these signals to the control unit and this automatically brings the weapon to the line-of-sight to the target. The effective range is dependent on the available speed and lateral acceleration after the burnout of the second stage motor. For long range targets the automatic guidance will cease after two or three seconds and after the missile is under control of the aimer's thumb.

To fire the gunner releases the safety catch and squeezes the trigger to activate the generator which supplies current to the thermal batteries in both the canister and missile. The gyro of the missile is run up by the action of the cordite burning charge, initiated by the thermal battery. The gas overpressure blows off the canister sealing cover. The missile is launched by the booster motor, which burns out before the missile exits from the tube and at a safe distance from the gunner. The missile is accelerated to supersonic speed by its sustainer motor.

After burnout it cruises as a fully controlled dart and is automatically gathered into the center view field of the gunner who then guides it to the target with the thumb-controlled joystick.

When the missile is being manually guided it is not necessary to keep the missile perfectly on track. The aimer only needs to keep the target in the field of view with the monocular. However if necessary the automatic guidance system can be disengaged and the missile flown to target on complete manual control.

The missile can be detonated by either a proximity or contact charge. The warhead is a dual blast shaped charge type and is capable of penetrating armor plate.

SPECIFICATIONS

TYPE: two stage low altitude

LENGTH

missile: 1.35 m
canister: 1.40 m

DIAMETER: 0.076 m

WING SPAN: 0.275 m

WEIGHT

aiming unit: 6.2 kg
missile: 11.0 kg
missile in canister: 14.5 kg

PROPULSION: dual-base solid propellant booster and sustainer rocket motors

GUIDANCE: IR-auto gathering, then command to line-of-sight (CLOS)

WARHEAD: 2.2 kg HE dual fragmentation shaped charge with contact and proximity fuze

MAX SPEED: Mach 1

MAX ENGAGEMENT RANGE: 3500 m

MIN EFFECTIVE RANGE: 700 m

MAX EFFECTIVE ALTITUDE: 2500 m

MIN EFFECTIVE ALTITUDE: 10 m

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DEPLOYMENT

Afghanistan (Mojahedin guerrillas), Argentina, Canada, Chile, Ecuador, Malawi, Nicaragua (Contra guerrillas), Nigeria, Oman, Pakistan, Portugal, Qatar, Thailand, United Kingdom

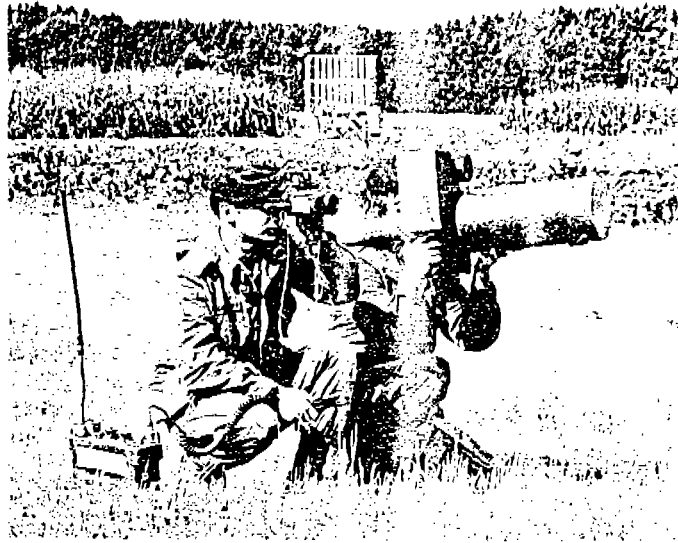


Figure A-11 Shorts Blowpipe

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UNITED STATES

General Dynamics FIM-92 Stinger Low Altitude Surface-To-Air Missile System

Description: A Stinger system (also referred as the FIM-92A) comprises the launcher assembly with a missile, a grip stock, an IFF interrogator, and an argon Battery Coolant Unit (BCU) which consists of a squib activated argon gas coolant unit and an electrical generating chemical battery.

The launcher assembly consists of a glass fiber launch tube with frangible end covers, a sight, coolant line, gyro-boresight coil, and a carrying sling. The grip stock is fitted with an Impulse Generator (BCU energized), a seeker head uncage bar, a weapons release trigger, an AN/PPX-1 IFF interrogator switch, and a foldable antennae.

The missile consists of a two stage solid propellant rocket motor and is fitted with a cooled passive conical scan reticle seeker with discrete electronic components that provide signal processing. The seeker processes the IR energy received from the target in the 4.1 to 4.4 μm wavelength region and determines the its relative angle and then, by using a proportional navigation guidance technique, continues to predict an intercept point.

In the FIM-92B version the reticle seeker unit is replaced by one which uses an optical processing system. This has two detector materials; one sensitive to IR and the other sensitive to UV energy. The two are incorporated into a single microprocessor which is integrated into the micro-electronic circuitry for the signal processor.

In all cases the seeker output is sent as steering data to the guidance assembly which converts it into a guidance signal format for the control electronics. This module then commands the two moveable (of four) control surfaces to maneuver the weapon onto the required intercept course. The control concept used is known as a single channel rolling airframe type and, as such, considerably reduces both the missile weight and manufacturing cost. As the weapon nears its target the seeker head activates its Target Adaptive Guidance (TAG) circuit within one second of impact to modify its trajectory away from the exhaust plume towards the critical area of the IR target itself. The fuzing system allows for both contact activation as well as missile self-destruct after 20 seconds of flight time following launch. The 3 kg Picatinny Arsenal warhead carried has a smooth fragmentation casing to ensure that the desired blast-fragmentation affect is achieved.

A typical engagement follows this sequence of events. Once alerted to a target the gunner shoulders the system, inserts the BCU into its grip-stock receptacle, and unfolds the IFF antennae. He then removes the front protector cover of the launcher tube to reveal the IFF or IR/UV transparent frangible disks, raises the open sight assembly and connects his belt pack IFF interrogator via a cable to the grip-stock. The gunner is now ready to visually acquire the target. He does this by using the sight and estimates its range with the estimation facility on the system. If required he now interrogates the target using the AN/PPX-1 IFF system. This can be done by the gunner without having to activate the weapon. The azimuth coverage of the 10 km range IFF system is essentially the same as that of the optical sight enabling the gunner to associate responses with the particular aircraft he has in view. An audio signal 0.7 seconds after the IFF challenge switch is depressed provides the gunner with the cue as to whether the target is friendly or not.

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If the target is unfriendly the gunner will track the target and activate the weapons system by depressing the impulse generator switch. This causes the impulse generator to energize the BCU which then releases its pressurized argon gas coolant to the IR detector and generates a dual polarity 20V DC output for at least 45 seconds to provide all the prelaunch electrical power required for the seeker coolant system, gyro spin up, launcher acquisition electronics, guidance electronics, activation of the missile's onboard thermal battery, and ignition of ejector motor.

The seeker is allowed to look at the target through the IR or IR/UV transparent front launcher disk and when sufficient energy is received by the detector for acquisition to occur an audio signal is sent to the gunner. Total time required for tracking and missile activation is about six seconds. He then depresses the seeker uncage bar and, using the open sight, inserts the super-elevation and lead data.

Once this is accomplished he depresses the firing trigger which activates the missile battery. This powers all the missile functions after launch and operates for approximately 19 seconds until the dual polarity 20V DC output drops below the required minimum for use. A brief time delay occurs following which the umbilical-connector to the grip-stock is retracted and a pulse is sent to ignite the ejector motor. Total time to motor ignition from depressing of the firing trigger is only 1.7 seconds. Upon ignition the initial thrust generated imparts roll to the missile airframe and starts the fuze timer system. The missile and its exhaust then breaks through the frangible disks at either end of the launcher tube.

Before the missile clears the end of the launch tube the ejector motor burns out in order to protect the gunner from the rocket blast and two movable control surfaces spring out. Once it clears the tube the folded tail fins open out and the ejector motor is jettisoned. The missile then coast to a predetermined safe distance where the fuze timer ignites the combined booster/sustainer rocket motor. When the correct acceleration rate is reached one second into the flight the warhead is armed and the self-destruct system timer is activated.

The seeker continues to track the target throughout the flight with the electronics processing the received signals to eliminate or reduce the line-of-sight pointing angle to the target. The weapon flies a proportional navigation path to the interception point near to which the TAG circuit is activated and a signal is generated within the seeker head to add bias to the steering signal causing the missile airframe to guide itself into a vulnerable part of the target.

The missile is capable of tracking an 8 g maneuver

SPECIFICATIONS

TYPE: two stage low altitude

LENGTH: 1.52 m (missile)

DIAMETER: 0.070 m (missile)

WING SPAN: 0.091 m

WEIGHT

missile: 10.1 kg

missile and launcher: 15.7 kg

PROPULSION: solid fuel ejector and boost/sustainer rocket motors

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GUIDANCE: passive IR (FIM-92A), passive IR/UV (FIM-92B/C)

WARHEAD: 3 kg HE fragmentation with contact fuze

MAX SPEED: Mach 2.2

MAX ENGAGEMENT RANGE: >4000m (FIM-92A), >4500 m (FIM-92B/C)

MIN ENGAGEMENT RANGE: 200 m

MAX ENGAGEMENT ALTITUDE: 3500 m (FIM-92A), 3800 m (FIM-92B/C)

MIN ENGAGEMENT ALTITUDE: ground level

DEPLOYMENT:

Afghanistan (Mojahedin guerrillas), Angola (UNITA guerrillas), Bahrain, Chad, Denmark, France, Germany, Greece, Israel, Italy, Japan, South Korea, Netherlands, Pakistan, Qatar, Saudi Arabia, Switzerland, Turkey, United Kingdom, United States



Figure A-12 FIM-92 Stinger

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General Dynamics FIM-43 Redeye Low Altitude Surface-To-Air Missile System

Description: The missile is sealed in its launcher and is not removed in the field before firing. It is fitted with a two-stage solid propellant rocket motor which acts as both the ejector and sustainer. The 2 kg warhead is an HE-fragmentation type and can be detonated when the contact fuze meets a solid object. However if no contact is made after 15 seconds of flight the missile self-destructs.

The Redeye comprises three components; the M62A2 moulded material launcher assembly, the M41 missile, and its launcher battery/coolant unit. The launcher includes an integral grip-stock fabrication, an open-sight aperture and cover, and the missile launcher-container tube. The front end seal of the latter is transparent to IR radiation to allow the missile seeker to sense the target. No IFF interrogator system is fitted so target identification left solely to the gunner's visual identification. Once he decides to engage a target he starts a sequence of actions which must not exceed 30 seconds due to the active life of the battery unit.

The first is to insert the battery/coolant device into the launcher's receptor and then, when the target is in range, he engages the safety and actuator system which activates the battery/coolant unit and sends liberated freon gas into the missile seeker where it expands to cool the IR detector.

The 7.5 power magnification open-sight with its 25° field-of-view is then placed on the target, and target range and elevation is determined in one operation. Any IR radiation received from the target is then allowed to focus through the front-end seal onto the seeker's detector cell. When sufficient energy is received to enable a lock-on to be achieved, an audible and visual signal indicates to the gunner that the missile has acquired the target. He then holds down the uncaging bar switch to uncage the weapon's gyro system, which has already spun up to speed, and depresses the firing trigger on the grip-stock. This causes an electric squib to ignite a thermite charge that melts an electrolyte in the battery which develops a 40 V output within 0.5 seconds. The missile ejector motor fires, the exhaust gas breaks through the rear frangible end cover seal and impinges on the folded tail-fins, and causes the weapon to spin within the tube. Once an acceleration of 28 g is reached an inertial switch in the fuze timer closes and the fuze timer circuit becomes live. The ejector motor burns out in a fraction of a second before the missile emerges through the front seal cover in order to protect the gunner from blast burns. During this brief coasting phase from the launcher muzzle, the four fixed tail-fins and the two moveable nose fins deploy. At 1.16 seconds into the flight, and approximately six to seven meters in front of the gunner's position, the timer fuze circuit ignites the second-stage sustainer motor, arms the warhead, and prepares it for detonation.

In the meantime the conical optical IR seeker is continually measuring the difference between the gyro line-of-sight and the IR source it is looking at. This data is converted into tracking error signals which are then used in a tracking servo-loop to continually re-position the

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seeker so that it stays aimed at the target. The use of this tail-chase proportional navigation guidance technique means that any violent maneuvering target, especially if it is deploying an IR decoy, has a very good chance of breaking the seeker lock and evading the missile.

During flight, canted nozzles impart roll to the missile which allows a single-axis control system to be used. The pair of 15° canted control fins near the nose are then commanded to snap in and out as required by this system, which is directed by the tracking guidance signals already generated by the seeker's IR homing package. Once in contact with the target the titanium warhead is detonated.

If it fails to hit a target after its set flight time the warhead automatically self-destructs.

SPECIFICATIONS

TYPE: two stage low altitude

LENGTH: 1.28 m (missile and launcher)

DIAMETER: 0.070 m (missile), 0.092 m (launcher)

WING SPAN: 0.140 m

WEIGHT

missile: 8.2 kg

missile and launcher: 13.1 kg

PROPULSION: solid fuel dual thrust ejector and sustainer rocket motor

GUIDANCE: passive IR

WARHEAD: 2 kg HE fragmentation with contact fuze

MAX SPEED: Mach 1.6

MAX ENGAGEMENT RANGE: 5500 m

MIN ENGAGEMENT RANGE: 500 m

MAX ENGAGEMENT ALTITUDE: 2700 m

MIN ENGAGEMENT ALTITUDE: ground level

DEPLOYMENT

Afghanistan (Mojahedin guerrillas), Chad, Denmark, El Salvador (FMLN guerrillas), Germany, Greece, Israel, Jordan, Nicaragua (Contra guerrillas), Saudi Arabia, Somalia, Sudan, Thailand, Turkey, United States

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Figure A-13 FIM 43 Redeye

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YUGOSLAVIA

SPDR Strela-2M/A Low Altitude Surface-To-Air Missile System

Description: The Strela-2M/A (Yugoslavian military designation S-2M/A) is a locally built derivative of the Soviet Strela-2M (SA-7).

The S-2M/A varies from the Soviet model in that the electronics system in the single channel passive IR seeker have been miniaturized, allowing the warhead section to be enlarged and increased in weight by 20% with the following advantages compared to the Strela-2M warhead:

- a) a 40% increase in weight of the explosive charges carried (0.518 kg versus 0.370 kg);
- b) a 40% increase in blast effects;
- c) a 30% increase in overall fragmentation effect;
- d) a 30% increase in total warhead efficiency;
- e) a 0.2% increase in a single shot kill probability

NOTE: This weapons system is utilized by all factions involved in the current Yugoslavian conflict.

SPECIFICATIONS

TYPE: two stage low altitude

LENGTH: 1.440 m (missile), 1.500 (launch tube)

DIAMETER: 0.072 m (missile)

WEIGHT

missile: 9.85 kg

missile and launcher: 15.00 kg

PROPULSION: solid fuel booster and solid fuel sustainer rocket motor

GUIDANCE: single-channel passive IR

WARHEAD: 1.32 kg HE-smooth fragmentation with contact and grazing fuze

MAX SPEED: Mach 1.5

MAX ENGAGEMENT RANGE: 4200 m (receding), 2800 m (approaching)

MAX TARGET ENGAGEMENT SPEED: 260 m/s (receding), 150 m/s (approaching)

MAX ENGAGEMENT ALTITUDE: 2300 m

MIN ENGAGEMENT ALTITUDE: 15 m

DEPLOYMENT

Croatian militia, Serbian militia, Slovenian Civil Defense (TO, Teritorijalna obramba), Yugoslavia

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Figure A-14 SPDR Strela-2M/A

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APPENDIX B
SOVIET/RUSSIAN MISSILE DESIGNATORS

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SOVIET/RUSSIAN MISSILE DESIGNATORS

Since the early 1980's the Soviet's/Russian's have introduced a system of designators for specific missile systems and components

Designator numbers and specific systems for MANPAD systems include:

SA-16 "Gimlet"

9M39: Launch Tube

9M313: Launch Tube

9M313-1: Launch Tube

9P515-2: Grip-Stock

SA-7 "Grail"

9K32: SA-7 System

9M32: SA-7a Missile

9K32M: SA-7b System

9M32M: SA-7b Missile

9b17: SA-7b Thermal Battery Supply Unit

9K32M1: SA-7c System

9M32M1: SA-7c Missile

9P54: Launch-Container Canister

9P54M: Launch-Container Canister

9P53: Grip-Stock

9P58: Grip-Stock

Other missile types include:

9M1xx: Anti-Tank Missiles

9M2xx: Unguided Rockets

9M3xx: SAMs

9M7xx: Surface to Surface Missiles

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**APPENDIX C
SAMPLE DATA COLLECTION SHEET**

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- 1) **TEST NUMBER:**
- 2) **DATE:** **TIME:**
- 3) **AIRCRAFT NUMBER:**
- 4) **AIRCRAFT MODEL:**
- 5) **PRIOR OBSERVABLE DAMAGE:**

- 6) **TYPE OF EXPLOSIVE USED:**
- 7) **TYPE OF DETONATOR USED:**
- 8) **QUANTITY OF EXPLOSIVE USED:**
- 9) **EXACT LOCATION OF WEAPON:**
 - A) **STATION:**
 - B) **STRINGER:**
 - C) **SIGNIFICANT DETAILS:**

10) PHOTOGRAPHIC EQUIPMENT

- A) **STILL CAMERAS (BODY, LENS, LENS SETTING, TYPE FILM)**
- B) **MOTION CAMERA (BODY, LENS, LENS SETTING, TYPE FILM)**

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C) CAMERA LOCATIONS IN RELATION TO AIRCRAFT DIAGRAM

11) WEATHER CONDITIONS:

A: TEMPERATURE:

B: WIND DIRECTION AND SPEED:

C: CLOUD COVERAGE:

D: SIGNIFICANT WEATHER ACTIVITY:

12) SHOT SUCCESS (YES OR NO):

13) IF NO, REASON FOR MALFUNCTION:

14) AIRCRAFT DAMAGE AFTER SHOT:

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